Additional note I:
'Residential Electricity Conservation Through Smart Home Energy Management Technology:
A Case-study in Milton, ON'

Submitted by Jeremy Schembri and Ian H. Rowlands (University of Waterloo)
19 February 2009

A query arose regarding the distribution of results (to supplement information regarding the 'average' of results). This brief note provides some information in response.

First, it is noted that, on p. 11 of the 2 February 2009 report, information about the range of results during the demand response events is provided; additionally, further details regarding each of the 19 homes are presented individually.

In this note, we have revisited the larger sample of 123 households, to supplement the 'average results' already presented (see, for example, Table 2 and Figure 1 on page 20 of the 2 February 2009 report) with additional details about the range of results.

Before, however, we present those results, we first make a comment about methodology. While much of our investigation, to this point, has matched any so-called 'sample household' (that is, a household that had the technology installed) with a so-called 'control household' (that is, a household with similar consumption characteristics that did not have the technology installed), we break from that tradition in this note. We do so namely because the isolated investigation of a simple 'sample-control' pair would have been too 'unstable' – relying too much on what happened in the 'control household' in that particular month (for example, did the inhabitants take a two-week vacation or, alternatively, have a houseguest for an extended period of time?). Instead, we – as will be elaborated below – 'control' with a larger sample of households. But, again, more about that is presented below.

First, however, we present 'absolute' information about the year-on-year change in electricity consumption (both total and peak) in our sample households. Remember that these are 'absolute' numbers and thus are not being controlled for temperature or any other 'external events'. They do, however, give a sense of the range of household experiences. More specifically, Table 1 presents the month-on-month percentage change for the 90th percentile and 10th percentile households – that is, these homes occupied these respective positions once all of the households' percentage changes were calculated and subsequently ordered (from high to low). Negative numbers mean reductions in consumption; positive mean increases. Table 1 suggests, therefore, that, in all months, more than 10% of the households experienced reductions in their total electricity consumption of at least 20%; similarly, in all months, more than 10% of the households experienced increases in their total electricity consumption of at least 17.5%. Analogous values for changes in peak consumption are 17.5% and 8%, respectively.

Table 1- Monthly absolute total and peak percentage consumption change of the participants of the 90th and 10th percentiles

	Total consumption		Peak consumption	
	90th percentile	10th percentile	90th percentile	10th percentile
October	-39.39%	90.46%	-43.17%	98.38%
November	-30.33%	53.85%	-29.36%	42.96%
December	-27.46%	32.29%	-29.33%	37.51%
January	-22.22%	33.46%	-24.18%	35.46%
February	-20.58%	55.68%	-17.96%	38.51%
March	-21.82%	34.67%	-38.04%	16.80%
April	-28.17%	39.41%	-26.87%	68.83%
May	-30.70%	46.83%	-46.11%	52.97%
June	-35.84%	32.30%	-45.67%	37.01%
July	-20.76%	55.41%	-23.49%	100.42%
August	-38.03%	17.54%	-53.84%	8.97%
September	-24.24%	29.51%	-27.21%	62.48%

*the intra- and inter-month results are not necessarily from the same household.

We can, moreover, attempt to 'control' these values to some extent. We do this by drawing upon the data for changes in consumption amongst all of our control houses (see Table 1, page 19 of the 2 February 2009 report). Our argument is that it is one thing to see that, for instance, year-on-year electricity consumption of the '90th percentile household' fell by 38% (total consumption) and 54% (peak consumption) between August 2007 and August 2008 (Table 1). It is, however, another thing to reflect upon how other factors (particularly weather) may have affected these changes. Table 2, for instance, reveals information about temperature for these two months from the University of Waterloo weather station. Indeed, the temperature was lower in 2008 than it was in 2007. Our previous report (Table 1, page 19 of the 2 February 2009 report) reveals that the 123 control households' total electricity consumption went from 119,471 kWh in August 2007 to 104,621 kWh in August 2008 (a reduction of 12%) and their peak electricity consumption went from 27,964 kWh to 19,957 kWh (a reduction of 29%). Thus, not all of the reductions seen by the '90th percentile household' should be attributed to the installation of the technology.

To continue the exploration, therefore, we take the data from Table 1 (about changes in electricity consumption among sample households) and 'temper' it with changes in the consumption of the control households over the same periods. More specifically, we subtract the change in the latter from the change in the former. To give this substance to this, the change in total and peak electricity consumption (respectively) we saw from August 2007 to August 2008 should not be viewed as 38% and 54% respectively (from Table 1), but instead should be 26% (38%-12%) and 25% (54%-29%) respectively. We do this repeatedly for every one of the 12 months under consideration. In Table 3, such results are presented.

Table 2 – Weather data reported by the University of Waterloo weather station

Summary for August 2007:	Summary for August 2008:
Maximum temperature 33.1 °C	Maximum temperature 28.6 °C
Minimum temperature 7.9 °C	Minimum temperature 6.9 °C
Average daily high temperature 25.5 °C	Average daily high temperature 24.1 °C
Average daily low temperature 14.3 °C	Average daily low temperature 13.1 °C

Table 3 – Electricity consumption reductions for 'top' sample households, with some 'control'

	Total consumption 90th percentile	Peak consumption 90th percentile
October	-40.76%	-51.19%
November	-32.50%	-31.37%
December	-29.83%	-29.23%
January	-23.34%	-23.96%
February	-22.93%	-22.62%
March	-25.59%	-26.12%
April	-24.50%	-38.94%
May	-23.72%	-22.92%
June	-23.53%	-21.98%
July	-27.69%	-35.29%
August	-25.60%	-25.21%
September	-18.36%	-30.63%

Across these 12 months, the total electricity reduction for the 'best 10%' was, on average, 27%; for peak electricity reduction, 30%. Considering just the summer months (which had full (123) participation), the respective figures are 24% and 27%.

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27 February 2009

In this document, we present the response to the question: 'what if the monthly analysis was applied to the whole year?' Below we have calculated the 'percentage change in consumption' (again, in the absence of any kind of control) for participants, year-on-year (that is, the year they had the technology, as compared with the previous year, when they did not have the technology). Again, we 'stacked' the results and pulled out the '10th' and '90th' percentile households. A couple of further points are worth noting:

1) Remember that not all participants were part of the trial for the full 12 months of our investigation. Therefore, when we say 'year-on-year', for some it is only 'five months-on-five months'. As a reminder, for 57 participants, it is 'year-on-year'; for all others, something less. (See, for example, Table 1 of the interim report we submitted on 22 December 2008 for more details.)

2) We have used two ways to calculate the difference, 'year-on-year'. First (what we call 'formula 1' below), we take, for each household, the entire consumption (for the year, or part thereof) and compare it with the previous year to calculate a percentage difference. And second (what we call 'formula 2 below), we take, for each household, monthly percentage changes in consumption (for every possible month in the year, compared with the previous year) and then average these monthly percentage changes. Results are presented in Table 1, below, and are analogous to the monthly results we presented in Table 1 (page 2) of our 'additional note' we submitted on 19 February 2009.

Table 1- Annual total and peak percentage consumption change of the participants of the 90th and 10th percentiles

	Total Consumption		Peak Consumption	
	90th Percentile	10th Percentile	90th Percentile	10th Percentile
Formula 1	-20.00%	25.46%	-27.05%	22.09%
Formula 2	-17.79%	23.53%	-20.68%	25.40%
Average of two approaches	-18.90%	24.50%	-23.87%	23.75%

As in our previous effort, we 'temper' this with some 'control' from changes in the control households' electricity consumption, year-on-year. From Table 1 of our 22 December 2008 report, we are able to calculate the control households' year-on-year change in consumption (weighted, it should be noted, by the varying levels of participation across the months of the year). The results of these calculations are presented in Table 2.

Table 2 – Changes in control households' annual total and peak consumption

Time-period	Total Consumption	Peak Consumption
October 2006 to September 2007	959,843 kWh	208,200 kWh
October 2007 to September 2008	934,213 kWh	195,394 kWh
Difference, 'year-on-year'	25,630 kWh	12,806 kWh
Percentage difference, 'year-on-year'	-2.67%	-6.15%

Given the results of Table 2, therefore, the reduction in total consumption reported in Table 1 should be 'made more modest' (moved from, say, -19% to -16%), as should the reduction in peak consumption (moved from, say, -24% to -18%).