NAVIGANT

Evaluation of the Impact of Sub-Metering on Multi-Residential Electricity Consumption and the Potential Economic and Environmental Impact on Ontario

Prepared for:

EnerCare Connections Inc.

Navigant Consulting Ltd.
1 Adelaide Street East
Suite 3000
Toronto, ON, M5C 2V9

416-777-2440
www.navigantconsulting.com

April 18, 2012

TABLE OF CONTENTS

1. Executive Summary

EnerCare Connections Inc. ("EnerCare") is a supplier of sub-metering services to multi-residential buildings in Ontario. Sub-metering[1] allows a landlord, property management firm, condominium corporation, or multi-tenant property[2] to bill tenants for individually measured electricity use. A multi-residential unit that is not sub-metered is billed on a "bulk" metering system. In residential apartment settings, under bulk metering, a unit is charged for electricity as a portion of their rent. This amount stays fixed from month to month (rent is normally fixed for the duration of an agreed-upon lease), and does not vary with the level of consumption.

For this study, EnerCare has retained Navigant Consulting Ltd. ("Navigant") to estimate the conservation impact of electricity sub-metering on multi-residential buildings and, based on this and publically available information, estimate the "technical potential" of a provincial deployment of sub-metering for multi-residential buildings. The technical conservation potential estimated in this report is defined in the following way: **the potential energy conservation that would accrue should the conservation technology[3] be adopted in every case in which it is feasible and has not already been implemented, as soon as is possible**.

The study's findings are significant: by introducing sub-metering in the multi-residential sector, the average electricity use is reduced by 34% for non-electrically heated buildings, and by 27% for electrically heated buildings. There are few measures available today that can reduce electricity use to this degree without the associated costs of major infrastructure upgrades.

If sub-metering were deployed in all currently bulk-metered multi-residential buildings, the annual potential electricity savings following complete deployment over five years could be 3.3 TWh – more than all of the electricity produced from Ontario's wind power facilities in 2010. Summer peak reduction potential could be 383 MW following complete deployment – the equivalent of just over half of the capacity of the Portlands Energy Centre in Toronto's waterfront.

Ontario has established mandatory conservation targets for Ontario's local distribution companies ("LDCs") to be achieved by 2014. Conservation programs to achieve these targets are funded by Ontario ratepayers and administered by the Ontario Power Authority ("OPA"), which is anticipated to invest $1.4 billion in conservation and demand management ("CDM") programs between 2011 and 2014.[4]

---

[1] In this report, unless the context indicates otherwise, "sub-metering" refers to both "unit smart metering" and "unit sub-metering" as defined in the *Energy Consumer Protection Act, 2010* (Ontario).

[2] For simplicity, these buildings will be collectively referred to as "multi-residential" buildings.

[3] In this case, sub-metering.

[4] As reported in numerous filings regarding LDCs, CDM plans and the resulting responses from the Ontario Energy Board ("OEB"). For example:
OEB Decision and Order for file EB-2011-0011 (Toronto Hydro-Electric System Ltd.),
http://www.torontohydro.com/sites/electricsystem/Documents/CDM2011/dec_order_THESL_CDM_20110712.pdf

To date, energy conservation from sub-metering has not been counted by the OPA or LDCs toward conservation targets. Integrating sub-metering in conservation program delivery would contribute to Ontario's conservation targets and could potentially deliver considerable benefits to the province in the form of costs savings associated with the reduced need for infrastructure investments due to energy conservation and environmental benefits.

Over a twenty-year period, the potential cost savings (in terms of investments for new generation assets, as well as transmission and distribution system upgrades) could be $2.73 billion. The reduction in greenhouse gases ("GHG") over the same twenty year period could be 22 thousand kilotonnes, approximately the same amount that was emitted by all private vehicles in Ontario in 2007.

A summary of the key findings is presented in Table 1.

Table 1: Summary of Key Findings

Conservation Impact of Sub-Metering
34% reduction in consumption, non-electrically[5] heated buildings
27% reduction in consumption, electrically heated buildings

Technical Conservation Potential*		
Annual Energy Savings	3.3	TWh
Peak Summer Demand Reduction	383	MW

Environmental Benefit*		
Annual avoided GHG emissions	1,200	Kilotonnes of CO_2e

Present Value of Avoided Costs (2013 through 2032) - Millions $2012		
Generation, Transmission and Distribution	$2,730	source: OPA[6]
Greenhouse Gas Emissions	$381	source: www.less.ca, NRCan
Total	**$3.1 billion**	

* Beginning in 2017, following the deployment of a sub-metering regime in the province from 2013 to 2017.

1.1 *Conservation Impact*

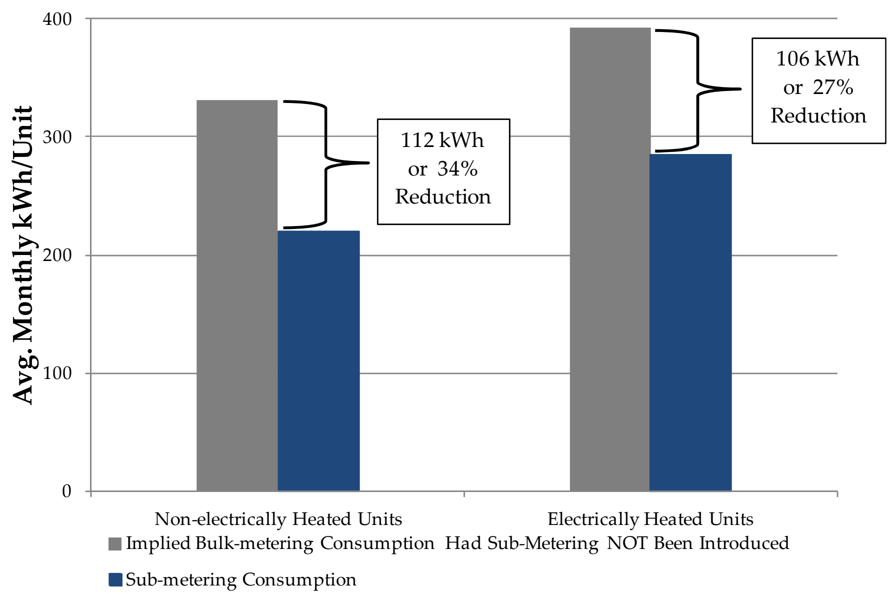
For this analysis, EnerCare provided Navigant with a sample of monthly data (including consumption, apartment square footage, etc.) for 3,971 units in 22 buildings in Ontario. To perform the conservation impact analysis, only monthly data for apartment units that switched from bulk metering to sub-metering were included. The resulting sample size was 608 units using gas as the primary fuel for space-heating, and 64 units using electricity as the primary fuel for space-heating.

[5] In this report, although EnerCare provided data only for units that were heated either primarily by gas or electricity, Navigant has assumed that the conservation impact estimated for primarily gas-heated units will be the same, on average, for all non-electrically heated units. In estimating technical potential therefore, Navigant has applied the savings estimated for gas-heated units to all non-electrically heated units included in the technical potential.

[6] Overall generation, transmission and distribution avoided costs presented here are a function of the OPA's avoided costs (per kWh of conservation and per kW of demand reduction) and the technical potential conservation estimated by Navigant. GHG avoided costs were determined as a function of the technical potential conservation estimated by Navigant and the cost per tonne of GHG charged by less.ca, assumed to be a reasonable proxy for the avoided costs of incremental GHG emissions. These assumptions are explained in greater detail in the body of the report below.

Navigant estimated that, on average, a switch from bulk to sub-metering will lead to a 112 kWh per month decrease in electricity consumption for those units that are primarily heated by gas, and a 106 kWh per month reduction in electricity consumption for those units that are primarily heated by electricity. This is a 34% and 27% reduction in consumption for non-electrically heated and electrically heated units, respectively. Figure 1 below summarizes the conservation impact from sub-metering. These results represent the average monthly kWh and percentage reduction that is realized when a unit switches from bulk to sub-metering.

Figure 1 - Conservation Impact



The annual reduction that is realized from a switch to sub-metering is 1,344 kWh for the average apartment unit that is primarily electrically heated, and 1,272 kWh for the average unit that is primarily gas-heated. A typical one bedroom apartment that is primarily gas-heated will see an annual average reduction of 1,164 kWh, while a two bedroom unit will see an annual reduction in consumption of 1,680 kWh. Similarly, a typical one and two bedroom unit that is primarily electrically heated will see an annual reduction in consumption of 960 and 1,308 kWh, respectively.

1.2 Technical Potential

Navigant made use of the robust estimates of the conservation effect of sub-metering drawn from its econometric analysis as well as the following to estimate the "technical" conservation potential (see definition below) of sub-metering in Ontario:

- Natural Resources Canada's ("NRCan") Comprehensive Energy Use Database (total provincial consumption by dwelling type, end-use, etc.)
- Statistics Canada's 2007 Census data (breakdown of population of different types of multi-residential buildings – condominiums greater than five stories, etc.)

- Internal EnerCare research (current level of penetration of sub-metering in Ontario)

The technical conservation potential estimated in this report is defined in the following way: **the potential energy conservation that would accrue should the conservation technology[7] be adopted in every case in which it is feasible and has not already been implemented, as soon as is possible**. A summary of the total number of condominium and apartment units in Ontario, and those to which sub-metering is applicable[8], are shown in Table 2 below.

Table 2: Condominiums and Apartments in Ontario

Apartments and Condominiums in Ontario		
	Apartment Units	Condominium Units
Total Number[9]	914,310	217,010
Number Applicable for Sub-Metering	264,733	144,184

In calculating the technical potential of sub-metering in Ontario, Navigant has assumed that as of January 1st, 2013, sub-metering will be implemented in every building in which it is feasible to implement sub-metering that is not already subject to sub-metering. This does not, however, mean that all units in all buildings will immediately become individually billed. Although condominium buildings tend to switch over all units at once, rental units tend to switch from bulk billing to sub-metered billing only with a change of tenancy. Thus, the implicit assumption is that all condominiums are sub-metered for the whole of 2013 as are a fifth of apartments (on a tenancy change), and that all applicable apartments are expected to be sub-metered by the end of 2017 since the tenancy of rental units is expected to fully "turn-over" in five years.

The estimated technical conservation potential for the years 2013 through the end of 2017 (the period required to roll out sub-metering to all applicable apartments, given tenancy turn-over) is shown in Figure 2 below. In the years following 2017, technical potential has been assumed to grow as suggested by the historical trend in multi-residential electricity consumption.

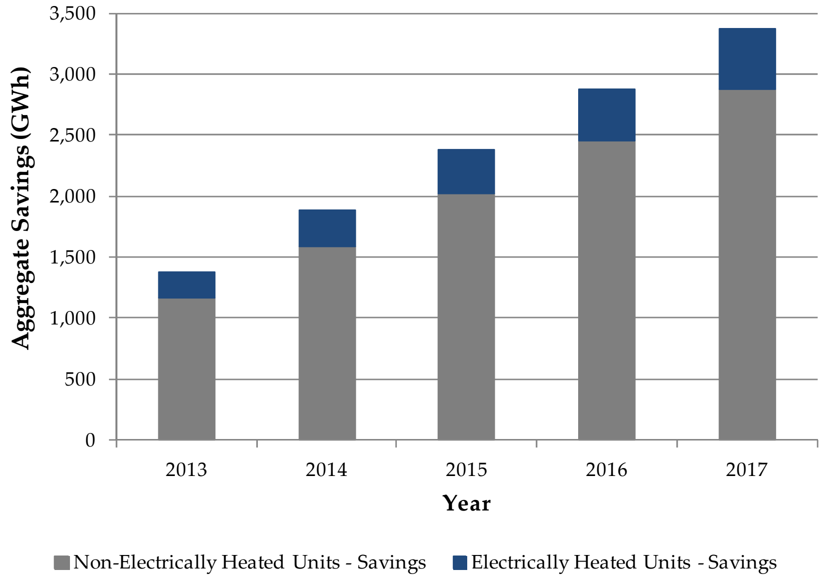
---

7 In this case, sub-metering.

8 Note that for the purposes of this study, units in buildings of less than five stories are considered non-applicable apartments since there is insufficient information available regarding the penetration of sub-metering amongst these units and the feasibility of implementing sub-metering in these buildings.

9 Statistics Canada, *2006 Census*, Topic-Based Tabulation: Structural Type of Dwelling and Housing Tenure and Presence of Mortgage for Occupied Non-Farm, Non-Reserve Private Dwellings of Canada, Provinces, Territories. http://www12.statcan.gc.ca/census-recensement/2006/dp-pd/tbt/Rp-eng.cfm?TABID=1&LANG=E&APATH=3&DETAIL=0&DIM=0&FL=A&FREE=0&GC=0&GK=0&GRP=1&PID=93641&PRID=0&PTYPE=88971,97154&S=0&SHOWALL=0&SUB=691&Temporal=2006&THEME=69&VID=0&VNAMEE=&VNAMEF=#DQF

Figure 2 - Projected Energy Savings (GWh) – Incremental by Year



Navigant estimates that the total cumulative technical potential over the five year period required to apply sub-metering to all applicable multi-residential units in Ontario would be approximately eleven terawatt hours. This is roughly the same as the total wind generation output from all grid-connected wind generation from 2007 through to the end of 2011. Following this initial roll-out period, potential annual savings could be approximately 3.3 TWh per year. The total cumulative technical potential over the twenty years from the beginning of 2013 to the end of 2032 could be as much as 62 TWh, or the equivalent of approximately five times the energy generated by wind power in Ontario from January 2006 to date.

Using the NRCan data and Ontario Power Authority end-use load shapes, Navigant has also estimated that the technical summer peak demand reduction, by 2017, of sub-metering in Ontario would be approximately 383 MW. This is the equivalent of just over half the capacity of the Portlands natural gas generating station in Toronto.

1.3 Societal Benefits: Avoided Generation Costs and Reduced Emissions

The societal benefits of energy conservation programs are typically quantified through the calculation of "avoided costs" benefits. "Avoided costs" are, in essence, the marginal costs to society of generating, transmitting and delivering incremental amounts of electricity and typically represent the costs of building and running generation assets and the transmission and distribution infrastructure.

For calculating the net present value of sub-metering over the five-year time window of the roll-out (2013 through the end of 2017) as well as over the first twenty years of deployment (2013 through the end of 2032), Navigant has used the avoided costs developed by the Ontario Power

Authority and included in its Conservation Resource Planning Tool. The Conservation Resource Planning Tool is a tool developed by the OPA to help local distribution companies plan their conservation programs.

As may be seen in Table 3 below, the present value of the avoided costs associated with the technical potential estimated over the first twenty years of sub-metering would be nearly two and a three quarter billion dollars (in 2012 dollars).

Table 3: Avoided Cost Benefits of Technical Potential

Avoided Cost Benefit Implied by Technical Potential (Millions, $2012)	
2013 through the end of 2017	$690
2013 through the end of 2032	$2,730

To calculate the range of estimated GHG emission reduction, Navigant has applied the average level of emissions estimated by the federal government[10] to result from power generation using a combined cycle gas turbine ("CCGT") – 0.36 tonnes per MWh. This value has been chosen because Navigant expects that a CCGT will generally be the marginal generation type in Ontario over the analysis period and thus the conservation effect of sub-metering would directly reduce the required energy output from CCGT generation facilities located in or serving the Ontario market.

Applying the figure to those cited above, Navigant estimates that the total cumulative reduction in greenhouse gas emissions over the roll-out period (2013 through 2017) would be over four thousand kilotonnes, and that over the longer, 20 year horizon (2013 through 2032) the total cumulative reduction in emissions would be approximately 22 thousand kilotons, approximately the same amount as was emitted by all private vehicles in Ontario in 2007.[11]

Table 4: Avoided Green House Gas Emissions

Avoided Green House Gas Emissions (kilotonnes)	
2013 through the end of 2017	4,282
2013 through the end of 2032	22,151

The OPA does not assign avoided costs to reduced GHG emissions, however, a rough approximation of the societal benefit of such reduced emissions may be estimated by using the

---

[10] Canada Gazette, *Reduction of Carbon Dioxide Emissions from Coal-Fired Generation of Electricity Regulations*, August 2011. http://www.gazette.gc.ca/rp-pr/p1/2011/2011-08-27/html/reg1-eng.html

[11] Statistics Canada, Greenhouse Gas Emissions From Private Vehicles in Canada, 1990 to 2007

http://publications.gc.ca/collections/collection_2010/statcan/16-001-M/16-001-m2010012-eng.pdf price charged by a David Suzuki Foundation-endorsed carbon offset vendor: Less (www.less.ca) charges $25 per tonne for Verified Emission Reduction Plus ("VER+") standard-certified offsets.

Using this value as the implicit societal benefit of carbon reductions, the present societal value of the avoided emissions implied by the estimated technical potential over the first twenty years if sub-metereing were deployed in all currently bulk metered multi-residential buildings in Ontario is approximately $381 million.

Adding this to the figure shown above in Table 3, the present value of the total societal benefit implied by the technical conservation potential of sub-metering is over three billion dollars (see Table 1 above).

2. Introduction

2.1 *Background*

EnerCare has retained Navigant to estimate the conservation impact of electricity sub-metering in multi-residential buildings and the technical conservation potential (and attendant economic and environmental benefits) of sub-metering in Ontario. For many multi-residential residents in Ontario, electricity is built into their monthly rent, and does not change with electricity usage. However, with a sub-metering infrastructure in place, the resident is billed separately for the electricity consumed and receives a monthly price signal linking their electricity consumption with their electricity costs. The application of prevailing economic theory suggests that in the face of such a price signal, aggregate multi-residential consumption should fall.

2.2 *Organization of This Report*

This report is divided into three main parts. The first part discusses the estimated conservation impact resulting from a switch from bulk metering to sub-metering, the data used for the analysis, and the methods employed to obtain estimates.

The second part of this report extrapolates these estimates out to a province-wide scale in order to estimate the "technical" conservation potential of an Ontario-wide deployment of sub-metering.

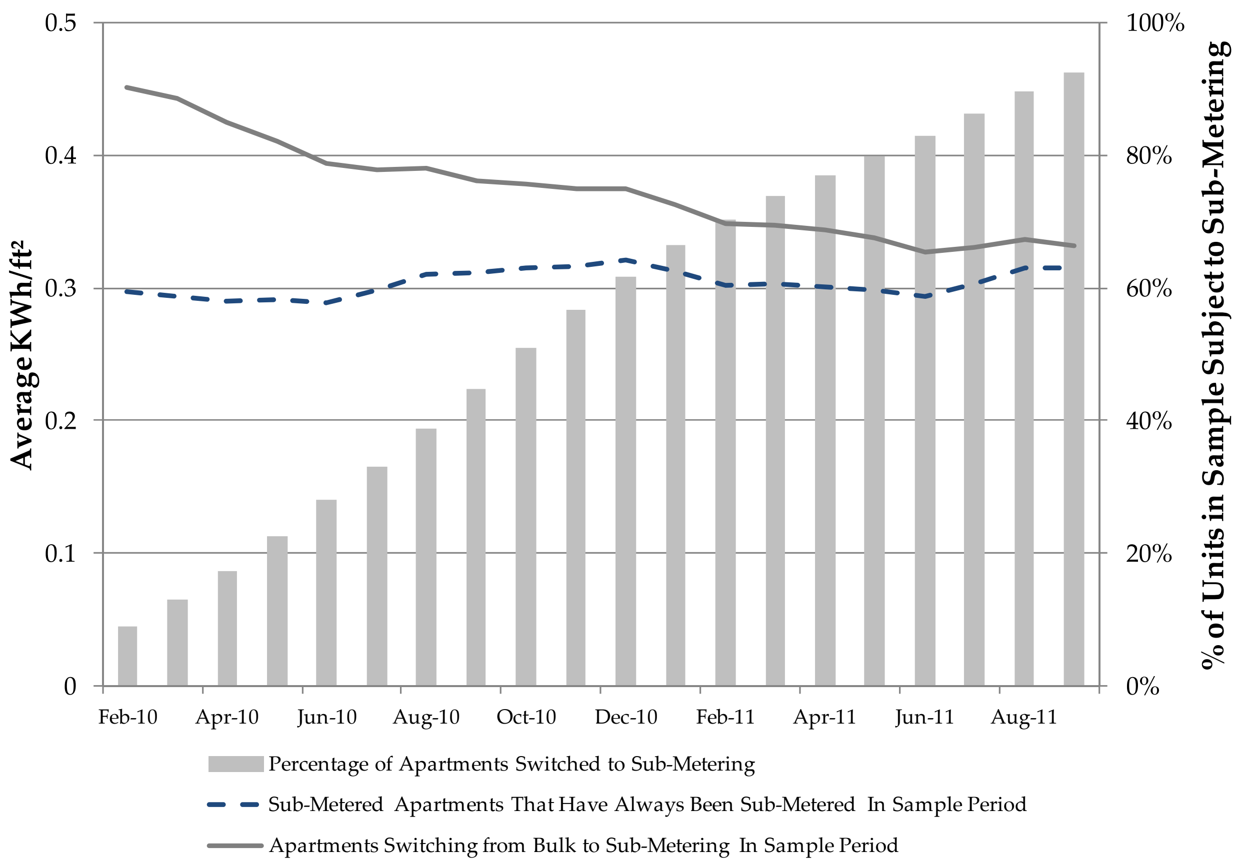
The third part of the report estimates the potential generation, transmission, distribution and GHG emissions and avoided cost benefits of such a deployment.

A detailed description of the econometric technique used for the conservation impact is provided in the appendix.

3. SUB-METERING CONSERVATION IMPACT

EnerCare has provided Navigant with the monthly consumption data of 3,971 multi-residential units from September 2009 through to September 2011. Of these, 34% are bulk metered for the entire sample, 49% are sub-metered for the entire sample and 17% switched from bulk metered to sub-metered at some stage during the time period of the sample. Figure 3 illustrates the average electricity consumption per square foot (left axis) for those who are sub-metered (blue dashed line) for the entire sample, and for those who switch from bulk metering to sub-metering at some point during the sampling period (dark grey line). The grey bar graph (right axis) illustrates the percentage of units subject to sub-metering within the group that switches from bulk to sub-metering at some point during the period of analysis. These graphs represent a rolling 6 month average of kWh per square foot and percentage of units. For this reason, the first date in the graph already consists of fewer than 10% of the units being sub-metered.

Figure 3: Average kWh/ft² Consumption



From this graph we can clearly see that over time, as units switch from bulk to sub-metering, their average electricity consumption decreases.

The following describes the data set used in the analysis, and the evaluation methods employed.

3.1 *Data Used for the Conservation Impact Analysis*

Navigant used the following data in estimating the conservation impact of sub-metering:

1. Altogether EnerCare provided monthly data for 3,971 apartments in 22 buildings. The dataset is from September 2009 through September 2011. Only data for apartment units that switched from bulk to sub-metering at some point in the sample were included in the analysis. Data from units that were already being sub-metered at the beginning of the dataset were not included, nor were data from units that did not switch from bulk to sub-metering. The monthly data include:
   a. Per unit monthly consumption (kWh);
   b. Unit size (square feet);
   c. Type of apartment (bachelor, 1 bedroom, etc.); and
   d. Principal heating fuel (electricity or gas).

2. Monthly heating and cooling degree days. This was calculated from the monthly average temperature at Pearson International Airport, and obtained from Environment Canada.

In total, the conservation impact for the gas-heated units was estimated using 608 units that switched from bulk to sub-metering within the time frame of our dataset. For the electrically-heated sub-sample, 64 units switched from bulk to sub-metering. The unit types within the buildings range from bachelor units to 3–bedroom units. Table 5 and Table 6 show the distribution of units and the average square footage of those units that switched from bulk to sub-metering.

Table 5: Unit Types and their Average Sizes for Gas-Heated Units Sub-Sample

Unit Type	Average Square Footage	Number of Units
Studio/Bachelor	367	96
1 Bedroom	626	250
1 Bedroom + 1 Den	875	7
2 Bedroom	904	219
2 Bedroom + 1 Den	1,075	7
3 Bedroom	1,266	29
Total		**608**

Table 6: Unit Types and their Average Sizes for Electrically-Heated Units Sub-Sample

Unit Type	Average Square Footage	Number of Units
1 Bedroom	606	14
2 Bedroom	823	42
3 Bedroom	1,100	8
Total		**64**

3.2 *Evaluation Methods*

This section describes the evaluation methods used by Navigant to estimate the conservation impact for both sub-samples.

To estimate the conservation impact, the data was divided into two sub-samples based on primary heating fuel: gas or electricity. Exploratory analysis of the data by the evaluation team indicated that the type of heating used for a particular unit was an important determinant of the estimated conservation impacts. The conservation impacts for our two sub-samples were estimated using fixed effects regression analysis applied to building level consumption panel data for 22 buildings in the Greater Toronto Area.

To estimate the impact of sub-metering, Navigant employed a statistical technique called "fixed effects." This technique is a form of linear regression that is often used for the estimation of the conservation and demand response program impacts and is considered the industry standard for this type of work. Fixed effects are a way of controlling for a variety of building characteristics that do not change over time. For example, the number of windows in a building, the direction it faces or the socio-economic make-up of the neighbourhood of which it is a part are unlikely to change in any significant way over the period of analysis, but will likely affect a building's level of electricity consumption. Rather than controlling for each individual characteristic, the analyst applied a fixed effect to each building which controls for all of that building's characteristics which do not change over the period of analysis.

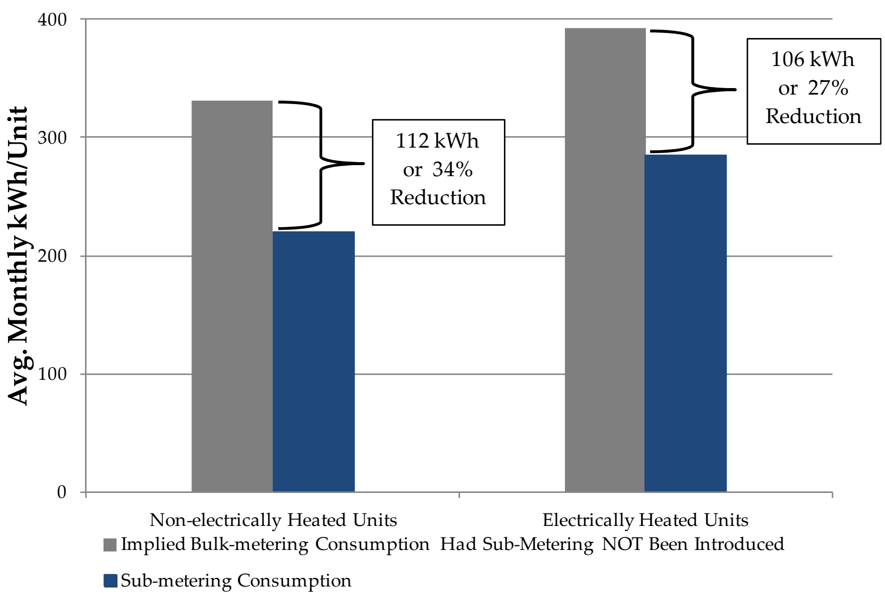
The basic unit of the data-set used to estimate the impact of sub-metering is a building and the number of square feet within that building that are, in any given month, subject to sub-metering. In addition to controlling for individual building characteristics that are time-invariant (through the inclusion of fixed effects), Navigant also included heating and cooling degree days in the model specification to control for seasonal variations in electricity consumption not related to the manner in which a customer is billed for his or her electricity consumption. A detailed description of the model specification used to estimate impacts may be found in the Appendix.

The regression equations used provide an estimated reduction in electricity consumption for every square foot that is switched from bulk to sub-metering. To obtain the overall percentage reduction and the average kWh reduction in consumption per unit, Navigant applied the estimated conservation impact (in kWh/ft^2) to the average size (ft^2) of all units within each sub-sample

3.3 Conservation Impacts

As may be seen in Figure 4 below, on average, a switch from bulk to sub-metering will lead to a 112 kWh per month decrease in electricity consumption for those units which use gas as their primary heating fuel, and a 106 kWh per month reduction in electricity consumption for those units which use electricity as their primary heating fuel. This is a 34% and 27% reduction in consumption for non-electrically and electrically-heated units, respectively.

Figure 4: Average Monthly kWh and Percentage Reduction



These estimates translate to an annual reduction of 1,344 kWh for the average apartment unit that is primarily gas-heated, and an annual 1,272 kWh reduction for the average unit that is primarily electrically-heated. A typical one bedroom apartment that is primarily gas-heated will see an annual average reduction of 1,164 kWh, while a two bedroom will see an annual reduction in consumption of 1,680 kWh. Similarly, typical one and two bedroom units that are primarily electrically-heated will see an annual reduction in consumption of 960 and 1,308 kWh, respectively.

3.4 Qualitatively Testing the Reasonableness of the Estimated Impact

This section demonstrates the reasonableness of the estimates shown above. Figure 5 and Figure 6 below compare the average consumption of units on sub-metering (blue line) with the average consumption of units on bulk metering (grey line) and the average level of consumption of sub-metered units *had they not been switched to sub-metering,* implied by the estimated impact (dashed blue line).

Visual inspection of the two figures below, particularly the degree to which the level and shape of the dashed blue line matches that of the dark grey line, strongly suggest that the estimated impacts are both accurate and reasonable.

Figure 5: Reasonableness Test of Estimated Impacts (Gas-Heated Units)

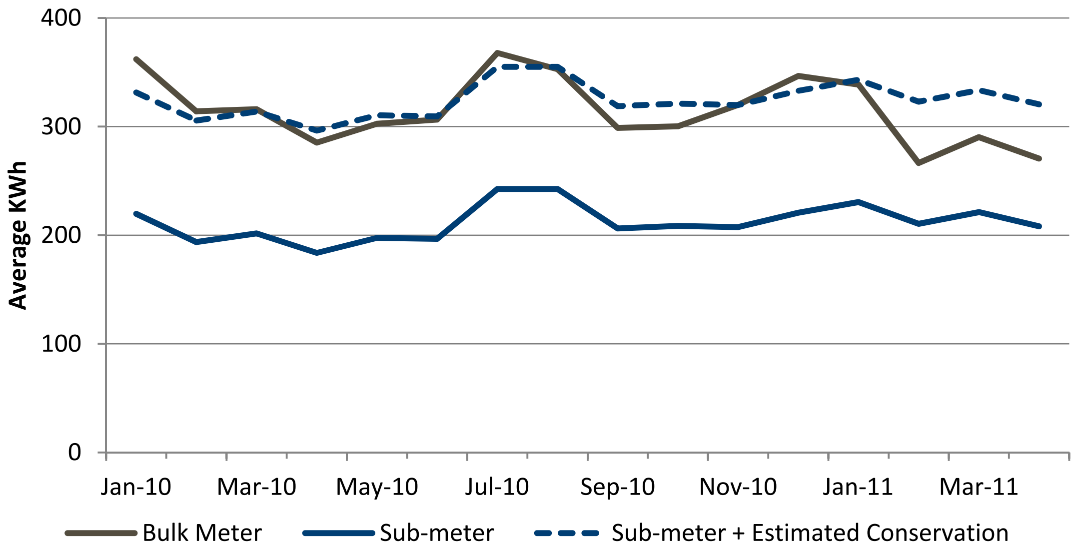
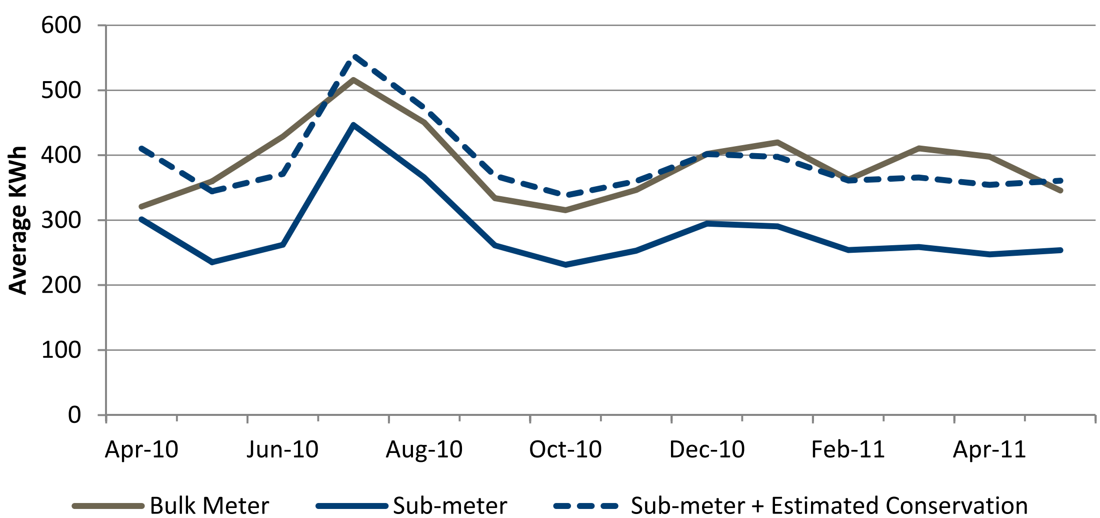


Figure 6: Reasonableness Test of Estimated Impacts (Electrically-Heated Units)



Note that the averages presented above are calculated from the sub-sample of units within the overall data set that switched from bulk to sub-metering at some point during the period of analysis. This has an implication for the date range presented for the qualitative reasonableness tests presented in Figure 5 and Figure 6.

While the sample used to estimate the conservation impact is from September 2009 to September 2011, the graph illustrates average consumption for the months January 2010 to April 2011. Only those months in which at least 15% of the units for both gas- and electrically-heated units are subject to bulk metering or sub-metering are included in the figures above. This curtailment of the sample is performed because it is unreasonable to compare two averages to one another when, for example, one is the average of 650 units while the other is the average of only twenty units.

3.5 *Conservation Impact per Unit Type*

This section presents the estimated conservation impacts for each of the unit types presented in Table 5 and Table 6 above. Table 7 and Table 8 below gives the average monthly consumption of each apartment that is sub-metered, the implied average monthly consumption absent sub-metering, and the monthly conservation impact (both in kWh and as a percentage) that results from a switch to sub-metering. A more detailed description of these calculations is provided on the next page and in the Appendix.

Table 7: Conservation Impact by Unit Type (Gas-Heated Units)[12]

Unit Type	Avg. Monthly kWh Sub-metering	Implied Avg. Monthly kWh Bulk Metering	Monthly Conservation Impact (kWh)	% Reduction in Consumption
Studio/Bachelor	138	195	-57	29%
1 Bedroom	199	295	-97	33%
1 Bedroom + 1 Den	287	422	-135	32%
2 Bedroom	283	423	-140	33%
2 Bedroom + 1 Den	321	487	-166	34%
3 Bedroom	368	563	-196	35%

Table 8: Conservation Impact by Unit Type (Electrically-Heated Units)[13]

Unit Type	Avg. Monthly kWh Sub-metering	Implied Avg. Monthly kWh Bulk Metering	Monthly Conservation Impact (kWh)	% Reduction in Consumption
1 Bedroom	224	305	-80	26%
2 Bedroom	299	408	-109	27%
3 Bedroom	342	488	-146	30%

[12] Due to rounding, some numbers may not sum precisely within table.

[13] Due to rounding, some numbers may not sum precisely within table.

To calculate the kWh and percentage reduction from sub-metering, the evaluation team applied the estimated conservation impact to the average size (in square feet) of each unit type. In order to calculate the percentage reduction in consumption, Navigant estimated what the average kWh for the units would have been *if* they had been bulk metered. To do this, the monthly conservation impact was added (as a positive number) to the average consumption of the units that are sub-metered. All else equal, the resulting "Implied Avg. Monthly kWh Bulk Metering" is the average consumption of that unit had it not switched from bulk to sub-metering, using the monthly conservation impact (in kWh) calculated from our fixed effects model.

4. Provincial Technical Conservation Potential

This section will estimate the aggregate energy, demand and greenhouse gas savings which may be realized if sub-metering were to be implemented in all applicable Ontario multi-residential buildings.

The potential estimated in this section is what is known as the "technical" potential for conservation. Technical potential is defined in the following way: **the potential energy conservation that would accrue should the conservation technology[14] be adopted in every case in which it is feasible and has not already been implemented, as soon as is possible**..

In calculating the technical potential of sub-metering in Ontario, Navigant has assumed that as of January 1st, 2013, sub-metering will be implemented in every building in which it is feasible to implement sub-metering that is not already subject to sub-metering. This does not, however, mean that all units in all buildings will immediately become individually billed. Although condominium buildings tend to switch over all units at once, rental units switch from bulk billing to sub-metered billing only with a change of tenancy. The technical provincial conservation potential of sub-metering will thus be quite large in 2013 (as all condominium buildings are assumed to switch) and then grow over a few years as bulk billed apartment residents are gradually replaced by sub-metered apartment residents.

The reader will note that in the previous section reference was made to gas- and electrically-heated units, whereas in this section reference is made to "non-electrically-heated" and electrically-heated units. This is due to the fact that the data provided by EnerCare covered only gas- and electrically-heated units, where as in the province as a whole a number of other non-electric fuel sources are used to provide space heat. Navigant has assumed that the conservation impact will be the same for all non-electric fuel types for the purposes of this component of the analysis and applied the gas-heated conservation result to all non-electric forms of space heat.

4.1 Baseline Consumption Estimation

Using the estimated percentage impacts shown above, along with NRCan's Comprehensive Energy Use Database[15], data from the 2006 Census[16], and a few assumptions (set forth below), it is

---

[14] In this case sub-metering.

[15] Natural Resources Canada, Office of Energy Efficiency, *Comprehensive Energy Use Database, 1990 to 2009,*

http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/comprehensive_tables/list.cfm?attr=0

[16] Statistics Canada, *2006 Census*, Topic-Based Tabulation: Structural Type of Dwelling and Housing Tenure and Presence of Mortgage for Occupied Non-Farm, Non-Reserve Private Dwellings of Canada, Provinces, Territories.

http://www12.statcan.gc.ca/census-recensement/2006/dp-pd/tbt/Rp-eng.cfm?TABID=1&LANG=E&APATH=3&DETAIL=0&DIM=0&FL=A&FREE=0&GC=0&GK=0&GRP=1&PID=93641&PRID=0&PTYPE=88971,97154&S=0&SHOWALL=0&SUB=691&Temporal=2006&THEME=69&VID=0&VNAMEE=&VNAMEF=#DQF

possible to extrapolate the impact of all applicable multi-residential buildings in Ontario switching to sub-metering.

NRCan provides data on the aggregate electricity consumption of all apartments and condominiums in Ontario between 1990 and 2008. It also provides the distribution of heating system stock amongst multi-residential buildings, the average efficiency levels of those heating systems and the total annual energy (electricity and otherwise) consumption of space-heating multi-residential buildings. The division of condominiums and rental units as well as large versus small buildings was drawn from the Census data. Using these five pieces of information, it is possible to reasonably estimate the annual electricity consumption of electrically and non-electrically heated multi-residential buildings in Ontario.

It may not be possible to switch all multi-residential units in Ontario to sub-metering. To start with, some percentage is already sub-metered. Based on internal research conducted by EnerCare, Navigant has assumed that half of the rental apartment buildings over five stories and 20% of condominium buildings over five stories in Ontario are sub-metered already and applied this to annual electricity consumption of multi-residential units to obtain the annual aggregate consumption of multi-residential units that are bulk metered.[17] Navigant has excluded all apartments and condominiums in buildings of less than five stories from the analysis of technical potential due to insufficient existing information regarding the penetration of sub-metering in these buildings. This effectively means that the potential discussed below excludes approximately 37% of all apartments and condominiums in Ontario. A tabular summary of total number of apartment and condominium units as well as applicable (i.e., over five storey, not already sub-metered) units is shown in Table 9 below.

Table 9: Condominiums and Apartments in Ontario

Apartments and Condominiums in Ontario		
	Apartment Units	Condominium Units
Total Number[18]	914,310	217,010
Number Applicable for Sub-Metering	264,733	144,184

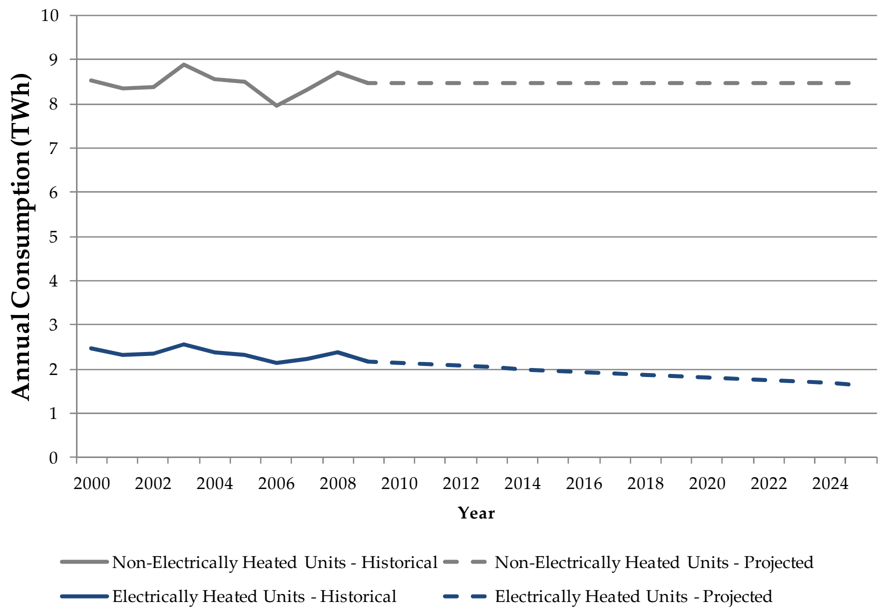
After applying the factors above, Navigant obtained the aggregate electricity consumption for non-sub-metered multi-residential units (both rental apartments and condominiums) to which sub-metering might be applicable, between 2000 and 2008 for both electrically and non-electrically

[17] Note that if 15% of multi-residential units are on sub-metering, they will represent less than 15% of consumption. They will represent 15% x (1-34%) = 10% of total consumption for non-electrically heated units and 15% x (1-26%) = 11% of total consumption for electrically heated units.

[18] Statistics Canada, *2006 Census*, Topic-Based Tabulation: Structural Type of Dwelling and Housing Tenure and Presence of Mortgage for Occupied Non-Farm, Non-Reserve Private Dwellings of Canada, Provinces, Territories. http://www12.statcan.gc.ca/census-recensement/2006/dp-pd/tbt/Rp-eng.cfm?TABID=1&LANG=E&APATH=3&DETAIL=0&DIM=0&FL=A&FREE=0&GC=0&GK=0&GRP=1&PID=93641&PRID=0&PTYPE=88971,97154&S=0&SHOWALL=0&SUB=691&Temporal=2006&THEME=69&VID=0&VNAMEE=&VNAMEF=#DQF

heated units. Navigant then proceeded to use this historical data to project consumption of these two types of multi-residential units. The projections are presented in Figure 7 below.

Figure 7: Applicable Apartment and Condominium Forecast Electricity Consumption (TWh)



4.2 *Estimate of Energy Savings*

To obtain an estimate of the overall technical provincial potential that sub-metering offers, Navigant then further assumed that:

1. The savings estimated above (34% for non-electrically heated buildings and 27% for electrically heated buildings) could be applied to all of the multi-residential buildings not explicitly excluded in the discussion above (i.e., buildings in which sub-metering could not feasibly be deployed).
2. On average, condominiums and rental units have approximately the same energy intensity.
3. The average size of condominiums is the same as that of rental apartments and that the average size of both condominiums and rental apartments is the same in buildings with five or more stories as it is in buildings with fewer than five stories.
4. The use of electricity as the principal space-heating fuel is distributed in a similar manner amongst both condominiums and rental apartments.

The assumptions above are specific to the analysis under consideration. The following additional assumptions are required for the calculation of technical potential (as it was defined above):

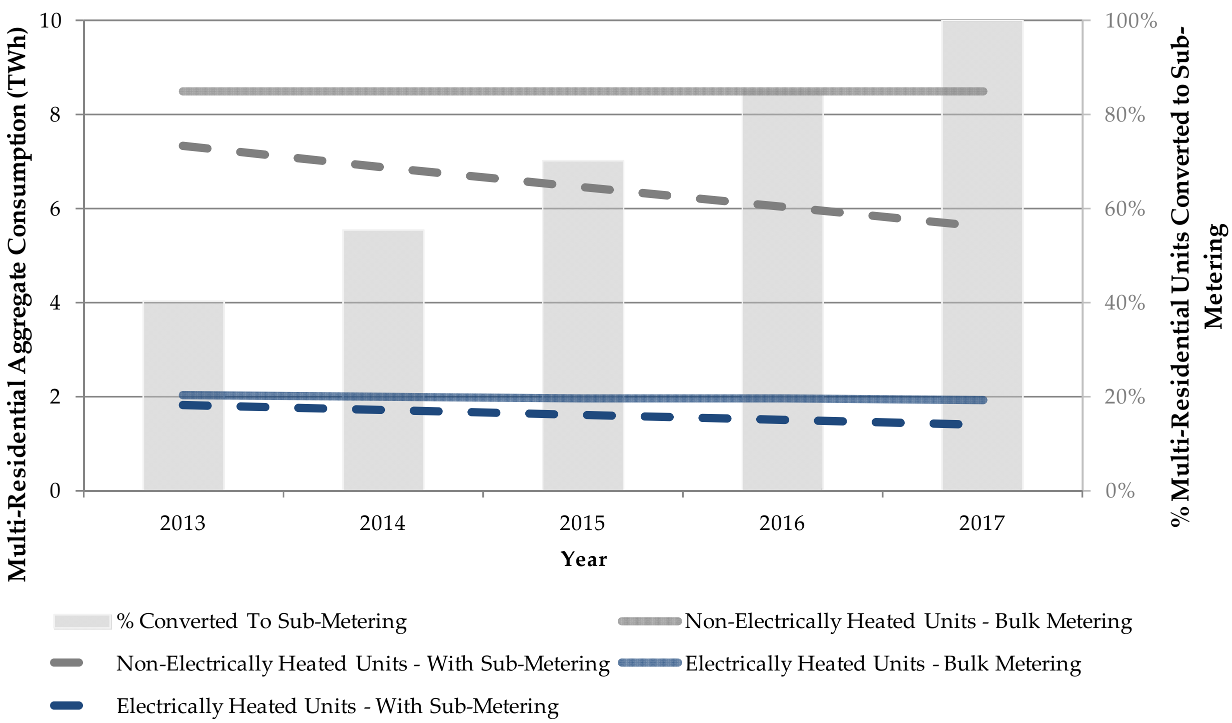
1. On average approximately 20% of rental apartments change tenants in each year (as per EnerCare internal research).
2. Every time a rental unit changes tenants, beginning in 2013, that unit becomes sub-metered.

3. As of 2013, all condominium buildings are sub-metered.

Applying these assumptions to the projected levels of consumption, we obtain a year-by year estimate of energy (TWh) savings. These are set out in Figure 8 below. In this chart the baseline consumption absent any sub-metering is represented by the solid lines, read at the left axis. Aggregate consumption assuming a gradual roll-out of sub-metering for apartments and a one-off roll-out to all condominiums by January 1st, 2013 (as specified above) is represented by the dashed lines, read at the left axis. The gap between the solid and dashed lines represents energy savings.

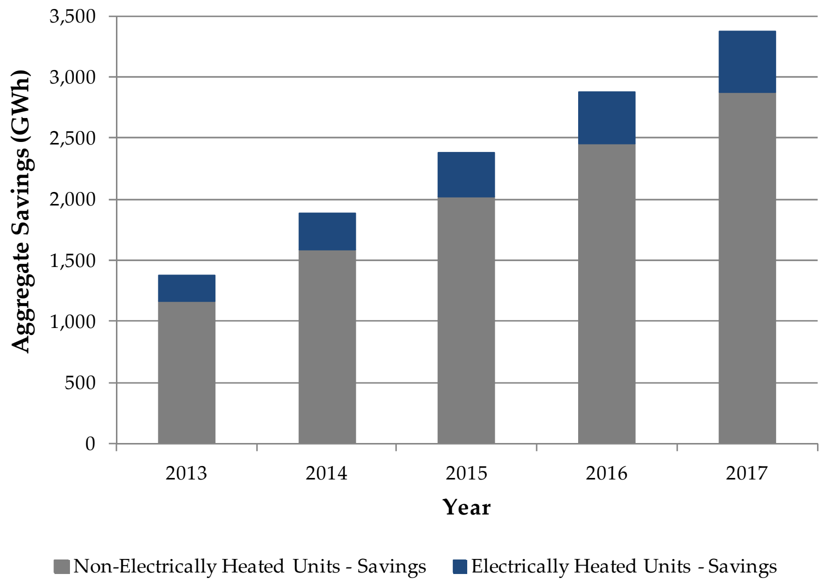
The faint grey bars are read at the right axis and express the percentage of consumption in each year which is assumed to now be sub-metered. Note the step-change that occurs in the first year of the period (2013), this is due to all condominium buildings (approximately a quarter of the applicable potential energy consumption) switching to sub-metering immediately in 2013. The more gradual turn-over of rental units from bulk billing to individual sub-metering may be observed in the gradual manner in which the dashed lines fall over the course of four years.

Figure 8: Projected Aggregate Multi-residential Consumption with Sub-Metering



Projected annual energy savings are shown in Figure 9 below. Navigant estimates that the cumulative savings over the five year period required to apply sub-metering to all applicable multi-residential units in Ontario would be approximately eleven TWh. This is roughly the same as the total wind generation output from all grid-connected wind generation from 2007 through to the end of 2011. The total cumulative technical potential over the twenty years from the beginning of 2013 to the end of 2032 could be as much as 62 TWh, or the equivalent of approximately five times the energy generated by wind power in Ontario from January 2006 to date. Beginning in 2017, following complete deployment by the end of 2016, annual potential savings could be approximately 3.3 TWh.

Figure 9: Projected Energy Savings (GWh) – Incremental by Year



4.3 Estimate of Peak Demand Reduction

Navigant has estimated the impact on peak demand of sub-metering by applying energy savings to a number of Ontario Power Authority end-use load shapes and peak coincidence factors ("CFs"). An overall multi-residential load shape is estimated as an average of several different end-use load-shapes, weighted by end-use consumption figures drawn from the same NRCan data set mentioned above.

The overall eight part OPA-style load shape and coincident factor for multi-residential buildings is presented in Table 10 below.

Table 10: Multi-Residential 8-part Load Profile and Peak Coincident Factor

	Winter			Summer			Shoulder	
	Peak	Mid	Off	Peak	Mid	Off	Mid	Off
Multi-Res - Non-Electrically Heated	7%	7%	16%	6%	11%	20%	15%	18%
Multi-Res - Electrically Heated	13%	12%	31%	3%	5%	10%	11%	16%

CF1		CF2	
Winter	Summer	Winter	Summer
1.2	1.1	1.3	1.1
1.1	1.1	1.2	1.1

From these load profiles, the total peak summer and winter demand reduction due to sub-metering may be calculated[19]. Given the total annual energy savings of just nearly 3.3 TWh projected for 2017, this implies a peak demand reduction of 565 MW in the winter and 383 MW in the summer. This is the equivalent of over half the capacity of the Portlands natural gas generating station in Toronto.

Note that the progression of demand reductions increases to this point proportionate to the energy savings shown in Figure 9.

[19] For this calculation, Navigant used the CF2 coincident factors which provide the average demand reduction over the top ten peak hours of the season in question. The CF1 coincident factors provide the average demand reduction over the single highest peak hour of the season.

5. Provincial Avoided Cost and GHG Reduction Benefits

This section estimates the societal benefits implied by the technical conservation potential: both benefits currently used in tests of societal cost-effectiveness by the Ontario Power Authority, and also external environmental benefits (as a result of GHG emission reduction) not yet included in those tests.

5.1 Generation, Transmission and Distribution Avoided Costs

The societal benefits of energy conservation programs are typically quantified through the calculation of the "avoided costs" benefits. "Avoided costs" are, in essence, the marginal costs to society of generating, transmitting and delivering incremental amounts of electricity and typically represent the costs of building and running generation assets and the transmission and distribution infrastructure.

For calculating the net present value of sub-metering over the five-year time window of the roll-out (2013 through the end of 2017) as well as over the first twenty years of deployment (2013 through the end of 2032), Navigant has used the avoided costs developed by the Ontario Power Authority and included in its Conservation Resource Planning Tool. The Conservation Resource Planning Tool is a tool developed by the OPA to help local distribution companies plan their conservation programs.

Calculation of the avoided costs also makes use of the load profile discussed above in section 4.3.

The present value of avoided costs, assuming an inflation rate of 2% and a social discount rate of 4%, is presented in Table 11 below, for the initial five years of technical potential, as sub-metering rolls out across the province, as well as for the first twenty years if sub-metering were deployed in all currently bulk metered multi-residential buildings in Ontario. As may be seen in Table 11 below, the present value of the avoided costs associated with the technical potential estimated, over the first twenty years, would be nearly two and three-quarters billion dollars.

Table 11: Avoided Cost Benefits of Technical Potential

Avoided Cost Benefit Implied by Technical Potential (Millions, $2012)	
2013 through the end of 2017	$690
2013 through the end of 2032	$2,730

5.2 *Estimate of Greenhouse Gas Emission Reduction*

To calculate the range of estimated GHG emissions reduction, Navigant has applied the average level of emissions estimated by the federal government[20] to result from power generation using a combined CCGT – 0.36 tonnes per MWh. This value has been chosen because Navigant expects that a CCGT will generally be the marginal generation type in Ontario over the analysis period and thus the conservation effect of sub-metering would directly reduce the required energy output from CCGT generation facilities located in or serving the Ontario market.

Applying the figure to those cited above, Navigant estimates that the total cumulative reduction in greenhouse gas emissions over the roll-out period (2013 through 2017) would be over four thousand kilotonnes, and that over the longer, 20 year horizon (2013 through 2032) the total cumulative reduction in emissions would be approximately 22 thousand kilotonnes, approximately the same amount as was emitted by all private vehicles in Ontario in 2007.[21] Beginning in 2017, following a complete deployment in 2016, annual GHG reductions could be approximately 1,200 kilotonnes per year. These results are summarized in Table 12 below.

Table 12: Avoided Green House Gas Emissions

Avoided Green House Gas Emissions (kilotonnes)	
2013 through the end of 2017	4,282
2013 through the end of 2032	22,151

The OPA does not assign avoided costs to reduced GHG emissions, however, a rough approximation of the societal benefit of such reduced emissions may be estimated by examining the cost of carbon offsets. In a 2009 study, the David Suzuki Foundation surveyed 20 different offset vendors[22] (both non- and for-profit) to assess the relative quality of these organizations. The highest scoring vendor – Less[23] - offers two types of offset. The Gold Standard-Certified International Offsets cost $45 per tonne and are derived from projects meeting the Gold Standard Foundation's sustainable development criteria. The VER+ Standard-Certified Canadian Offsets cost $25 per tonne and are sourced from projects that have achieved certification under the VER+ Standard, the current global standard of emissions offsets.

---

[20] Canada Gazette, *Reduction of Carbon Dioxide Emissions from Coal-Fired Generation of Electricity Regulations*, August 2011. http://www.gazette.gc.ca/rp-pr/p1/2011/2011-08-27/html/reg1-eng.html

[21] Statistics Canada, Greenhouse Gas Emissions From Private Vehicles in Canada, 1990 to 2007

http://publications.gc.ca/collections/collection_2010/statcan/16-001-M/16-001-m2010012-eng.pdf

[22] David Suzuki Foundation, Purchasing Carbon Offsets: A Guide for Canadian Consumers Businesses and Organizations, August 2009.

http://www.davidsuzuki.org/publications/downloads/2009/climate_offset_guide_web.pdf

[23] www.less.ca

Using the value of the VER+ Standard, the present societal value (assuming a 4% social discount rate) of the avoided emissions implied by the estimated technical potential over the first twenty years if sub-metering were deployed in all currently bulk metered multi-residential buildings, is approximately $381 million.

6. Appendix

6.1 Conservation Impact Analysis

For the analysis presented in this report, EnerCare provided Navigant with monthly data for 3,971 units in 22 buildings in Ontario over 25 months. Only units that switched from bulk to sub-metering were used to estimate the conservation impact, resulting in a sub-sample size of 608 units for gas-heated buildings and 64 units for electrically heated buildings.

To estimate the impact of sub-metering, Navigant employed a statistical technique called "fixed effects." This technique is a form of linear regression that is often used for the estimation of the conservation and demand response program impacts and is considered the industry standard for this type of work. Fixed effects are a way of controlling for a variety of building characteristics that do not change over time. For example, the number of windows in a building, the direction it faces or the socio-economic make-up of the neighbourhood of which it is a part are unlikely to change in any significant way over the period of analysis, but will likely affect a building's level of electricity consumption. Rather than controlling for each individual characteristic, the analyst applies a fixed effect to each building. This fixed effect controls for all of that building's characteristics which do not change over the period of analysis. In statistical jargon, applying fixed effects is functionally the same as including a separate dummy variable for each building in the equation, to control for that building's individual, time-invariant, characteristics.

The cross-sectional unit of analysis for estimating the conservation impact is the building, not the unit. That is, the panel (or longitudinal) data set used to perform the regression contains an observation of each building's level of consumption in each month, as opposed to each unit's.

In addition to controlling for individual building characteristics that are time-invariant (through the inclusion of fixed effects), Navigant also included heating and cooling degree days in the model specification to control for seasonal variations in electricity consumption not related to the manner in which a customer is billed for his or her electricity consumption. Algebraically, the model is presented as:

$$\boldsymbol{y_{it} = \alpha_i + \beta_j X_{it} + \gamma SF_{it} + \varepsilon_{it}} \tag{1}$$

Where:

y_{it} = The kWh consumption of building *i* in month *t*

α_i = The fixed effect corresponding to building *i*

X_{it} = A set of observable variables applicable to building i in month t. This set includes heating and cooling degree days and total square footage of all fully occupied units in each month (both sub-metered and bulk metered).[24]

SF_{it} = Total square footage of all units in each month that are sub-metered.

β_j = The parameter estimates for our set of observable variables, X_{it}

γ = The parameter estimate for the SF_{it} variable.

The parameter estimates corresponding to the variable of interest (SF_{it}) for the fixed effect models for primarily gas-heated and electrically-heated units are detailed in Table 13 below.

Table 13: Model Results

Heating Type	Parameter Estimate: γ	Standard Error	p-value
Gas	-0.15	0.008	<.0001**
Electric	-0.13	0.020	<.0001**

**Indicates significance at 5%

From these parameter estimates, we can conclude that a switch to sub-metering, all else being equal, will result in 0.15 kWh per square foot reduction of electricity consumption for gas-heated units, and 0.13 kWh per square foot for electrically heated units.

6.1.1 Average kWh and Percentage Reductions

To calculate the kWh and percentage reduction from sub-metering, Navigant applied the estimated conservation impact to the average size (in square feet) of all units within each sub-sample (gas and electrically heated). In order to calculate the percentage reduction in consumption, Navigant estimated what the average kWh for the units implied by the parameter estimates if those units *had* been bulk metered. To do this, the monthly conservation impact (in kWh) was added (as a positive number) to the average consumption of the units that are sub-metered. All else equal, the resulting "implied average monthly kWh bulk metering" is the average consumption of those units had they not switched from bulk to sub-metering, using the kWh reduction calculated from our fixed effects model. Table 14 below summarizes these results.

---

[24] While total building area would normally be controlled for under a fixed effects model, some observations had to be dropped from the analysis. For example, we did not include units that were vacant in a given month since these units would be in no way sensitive to the manner in which their consumption is billed. This means that it is possible – in the data-set – for total square footage of various buildings to vary from month to month.

Table 14: Average kWh and Percentage Reductions[25]

Sub-Sample	Average ft² of units in sub-sample	Avg. Monthly kWh Sub-metering	Implied Avg. Monthly kWh Bulk metering	Monthly Conservation Impact (kWh)	% Reduction in Consumption
Gas-Heated	725	219	332	-112	34%
Electrically-Heated	811	287	394	-106	27%

[25] Due to rounding, some numbers may not sum precisely within table.