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.
Bay Adelaide Centre
333 Bay St., Suite 1250
Toronto, ON, M5H 2R2

416-777-2440
www.navigant.com

January 8, 2016

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, electricity is built into the tenant's monthly rent, and does not change with electricity usage. However, with sub-metering, the resident is billed individually for the electricity consumed and thus receives a monthly price signal linking their electricity costs with their electricity consumption. The application of prevailing economic theory suggests that in the face of such a price signal, aggregate multi-residential electricity consumption should fall.

Enercare retained Navigant Consulting Ltd. ("Navigant") to estimate the conservation impact of electricity sub-metering on multi-residential buildings and, based on this and information provided by Enercare, estimate the "technical conservation potential" of a provincial deployment of sub-metering for multi-residential buildings.

The study's findings are significant: a unit (apartment or condominium) converted from bulk to sub-metering yields annual electricity savings of approximately 40%, savings that Navigant's testing indicates persist largely unchanged over time. Navigant is not aware of any conservation program being offered in Ontario or elsewhere that can achieve such high and persistent savings. To put this level of savings into perspective, report-based behavioural programs, such as those offered by OPower and other service providers, typically achieve savings in the range of 2 – 3%.

Navigant estimates, based on the per unit savings given above, that if sub-metering were deployed in all currently bulk-metered multi-residential buildings in the province, the annual potential electricity savings following complete deployment after five years could be over 1 TWh per year. Annual summer peak reduction potential could be 158 MW following complete deployment.

Ontario has established conservation targets for Ontario's local distribution companies ("LDCs") to be achieved by 2020 under the new Conservation First Framework. Conservation programs to achieve these targets are funded by Ontario ratepayers and administered by the Independent Electricity System Operator ("IESO"), with a goal of reducing electricity consumption by 8.7 TWh by December, 2020.[3]

To date, energy conservation from sub-metering has not been counted by the IESO or LDCs toward conservation targets. Integrating the conservation results achieved by sub-metering would significantly contribute to Ontario's conservation targets and would 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.

---

[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] http://www.ieso.ca/Pages/Conservation/Conservation-First-Framework/default.aspx

Over a twenty-year period, the potential avoided costs (in terms of investments for new generation assets, as well as transmission and distribution system upgrades) could be approximately $1.2 billion (present value, 2015 dollars). The reduction in greenhouse gases ("GHG") over the same twenty year period could be over 7,000 kilotonnes, the equivalent of 1.5 million passenger vehicles driven for one year.[4]

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

Table 1: Summary of Key Findings[5]

Conservation Impacts of Sub-metering	
Reduction in consumption in 1st year on sub-metering	**40%**
Reduction in consumption in 2nd year on sub-metering	**37%**
Reduction in consumption in 3rd year on sub-metering	**39%**
Reduction in consumption in each subsequent year	**39%**

Apartments and Condominiums in Ontario		
	Apartment Units	Condominium Units
Applicable to Sub-Metering	439,238	261,000

Annual Technical Conservation Potential by 2022 (Full deployment)		
Energy	1.1	TWh
Peak Summer Demand	158	MW

Environmental Benefits		
Potential annual avoided GHG emissions by 2022	389	Kilotonnes of CO_{2e}
Potential cumulative avoided GHG emissions (2016 through 2035)	7,322	Kilotonnes of CO_{2e}

Present Value of 20 Years of Avoided Costs (2016 through 2035) - Millions $2015		
Generation, Transmission and Distribution	$1,190	Source: IESO
Greenhouse Gas Emissions	$126	Source: www.less.ca
Total	**$1,316**	

Source: Navigant Analysis

1.1 Conservation Impact and Savings Persistence

For this analysis, Enercare provided Navigant with a sample of monthly consumption data for 5,137 units in 49 buildings in Ontario. To perform the conservation impact analysis, only monthly data for apartment units that switched from bulk metering to sub-metering in the sample period were

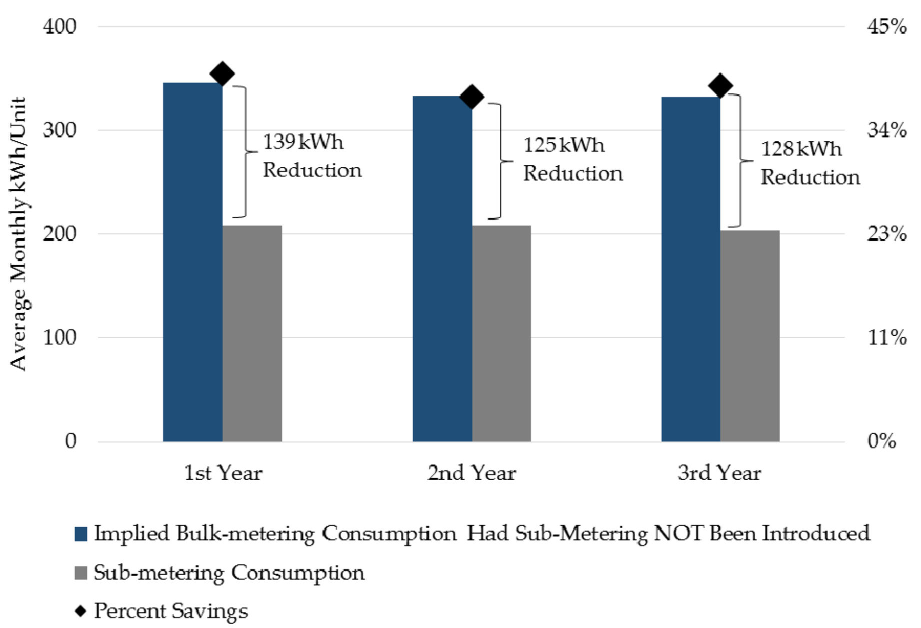
[4] United States Environmental Protection Agency Greenhouse Gas Equivalencies Calculator: http://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

[5] Conservation impacts presented below and within this report represent the reduction in unit-level consumption relative to what consumption had been absent sub-metering.

included. The resulting sample size was 1,500 units across 47 buildings that do not use electricity as the primary fuel for space-heating.

Navigant estimates that, on average, a switch from bulk to sub-metering will lead to a 139 kWh per unit (per month) decrease in electricity consumption in the first year of sub-metering. Savings decay slightly in the second year of deployment, falling to 125 kWh/month, but then increase again to 128 kWh in the third year of deployment and persist at this level going forward. These impacts represent a 40%, 37%, and 39% reduction in electricity consumption, 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 in the first, second, and third years for which that unit is subjected to sub-metering. Changes in the savings values after the third year of deployment were not found to be statistically significant, indicating that savings in all subsequent years observed in the sample are equivalent to those estimated for the third year of deployment.

Figure 1: Conservation Impact



Source: Navigant analysis

The annual reductions that are realized from a switch to sub-metering are shown in Table 2. The initial reduction in consumption (Year 1) from a switch to sub-metering results in an annual reduction of 1,664 kWh. A unit subjected to sub-metering for two and three years reduces consumption by 1,501 and 1,542 kWh compared to what would have been consumed under bulk metering, respectively. As noted above, changes in savings after the third year were not found to be statistically significant, indicating that savings in all subsequent years are equivalent to those estimated for the third year of deployment.

Table 2: Annual Average Savings per Unit (kWh)

1st Year	2nd Year	3rd Year	Each Subsequent Year
1,664	1,501	1,542	1,542

1.2 *Technical Potential*

Navigant used the "per unit" conservation impact and savings persistence estimates from its econometric analysis as well as the following to estimate the technical conservation potential (see definition below) of sub-metering in Ontario:

- Internal Enercare research (number of potential units applicable to sub-metering in Ontario).
- End-use load shapes developed by the IESO and included in its CDM Energy Efficiency Cost Effectiveness Tool.[6] This tool was developed by the IESO to help LDCs plan their conservation programs
- Natural Resources Canada's ("NRCan") Comprehensive Energy Use Database (total provincial consumption by dwelling type, end-use, etc.)[7]

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[8] be adopted in every case in which it is feasible and has not already been implemented, as soon as is possible**. This conservation potential does not include any conservation impact from space-heating consumption for units where the primary heating fuel is electricity. This exclusion is driven by issues of data availability covered in greater detail below. A summary of the total number of condominium and apartment units available for sub-metering in Ontario is shown in Table 3 below. These figures include total provincial values provided by Enercare in addition to those units that were included in the sample data provided by Enercare that did not switch to sub-metering during the study period. It does not include units that have already switched to sub-metering.

Table 3: Condominiums and Apartments Applicable to Sub-Metering in Ontario

	Apartment Units	Condominium Units
Applicable to Sub-Metering	439,238	261,000

In calculating the technical potential of sub-metering in Ontario, Navigant has assumed that as of January 1st, 2016, sub-metering will be implemented in every building in which it is feasible but not yet present. 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-meter billing only with a change of tenancy. Thus, the implicit assumption is that all condominiums are sub-metered for the whole of 2016 as are a fifth of

---

6 http://www.powerauthority.on.ca/opa-conservation/conservation-first-framework-tool-kit/guidelines-and-tools

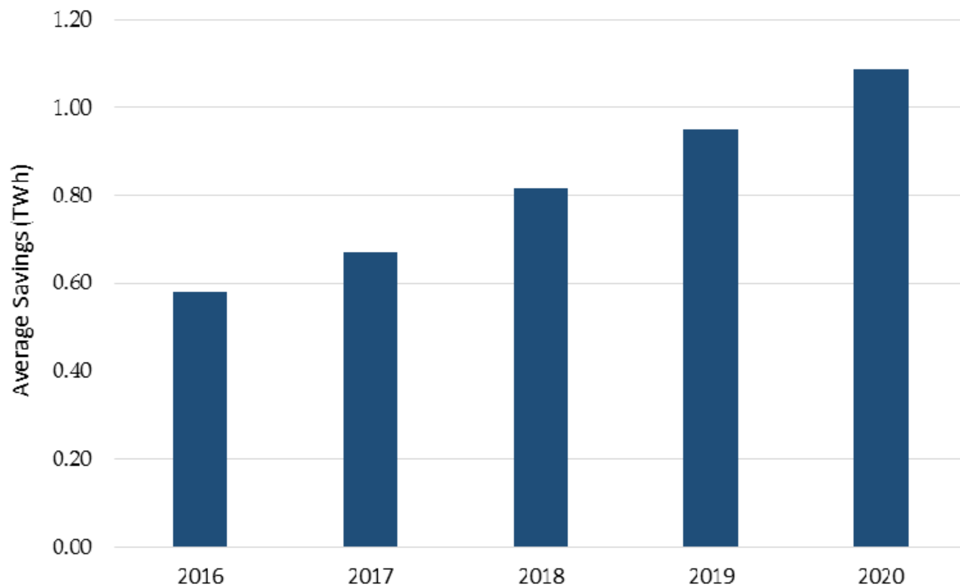
7 http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/menus/trends/comprehensive/trends_res_on.cfm

8 In this case, sub-metering.

apartments (on a tenancy change), and that all applicable apartments are expected to be sub-metered by the end of 2020 since the tenancy of rental units is expected to fully "turn-over" in five years.

The estimated technical conservation potential for the years 2016 through the end of 2020 (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 2020, technical potential has been assumed to grow as suggested by the historical trend in multi-residential electricity consumption.

Figure 2: Projected Energy Savings (TWh) – Incremental by Year



Source: Navigant Analysis

Assuming that a change of tenancy occurs in all applicable rental units in Ontario over the five-year period, resulting in a switch from bulk billing to sub-meter billing for all such units, 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 4.1 TWh. Following this initial roll-out period, potential annual savings could be more than 1 TWh per year, approximately 5 times the net annual savings of the entire 2014 Consumer Initiatives Portfolio.[9,10] The total cumulative technical potential over the twenty years from the beginning of 2016 to the end of 2035 could be as much as 20 TWh.

As noted above, these savings do not include any incremental conservation impacts derived from the reduction of electric space-heating consumption in buildings where electricity is the primary space-heating fuel.

---

[9] Research into Action on behalf of the OPA, *2014 Consumer Program Evaluation Volume 1: Report*, 2015 http://www.powerauthority.on.ca/sites/default/files/conservation/2014-Evaluation-Consumer-Initiatives.pdf

[10] The five consumer energy efficiency initiatives included in the portfolio are: The bi-annual retailer coupons event, the annual coupons initiative, the appliance recycling initiative, appliance exchange imitative, and the heating, ventilation, and conditioning incentives initiative. Net annual savings reflect initiative-specific net-to-gross ratios.

Using the NRCan data, Navigant has also estimated that the technical summer peak demand reduction, by 2022 (full deployment), of sub-metering in Ontario would be approximately 158 MW.

1.3 Societal Benefits: Avoided Generation, Transmission, and Distribution Costs

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 (2016 through the end of 2020) as well as over the first twenty years of deployment (2016 through the end of 2035), Navigant has used the avoided costs developed by the IESO and included in its CDM Energy Efficiency Cost Effectiveness Tool.[11] This tool is developed by the IESO to help LDCs plan their conservation programs.

As may be seen in Table 4 below, the present value of the avoided costs (including avoided energy and capacity costs) associated with the technical potential estimated over the first twenty years of sub-metering would be approximately $1.2 billion dollars (in 2015 dollars).

Table 4: Avoided Cost Benefits of Technical Potential

Avoided Cost Benefit Implied by Technical Potential (Millions, $2015)	
2016 through the end of 2020	$280
2016 through the end of 2035	$1,190

1.4 Societal Benefits: GHG Reduction

Navigant estimated both the historical avoided GHG emissions of units that have been converted to sub-metering since January 2013 through to October 2015, and the potential avoided GHG emissions through to the end of 2035 using the applicable apartment and condominium units presented in Table 3.

To calculate the range of estimated GHG emission reduction, Navigant has applied the estimated average level of emissions 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 resource in Ontario over the analysis period and thus the conservation effect of sub-metering would directly reduce the required output from CCGT generation facilities located in or serving the Ontario market.

[11] http://www.powerauthority.on.ca/opa-conservation/conservation-first-framework-tool-kit/guidelines-and-tools

Applying the figure to the units included in the estimation sample that have been converted to sub-metering from January 2013 through to October 2015, Navigant estimates that the historical avoided GHG emissions are approximately 2.74 kilotonnes.

The total cumulative reduction in greenhouse gas emissions over the roll-out period (2016 through 2020) could be approximately 1,481 kilotonnes. Over the longer, 20 year horizon (2016 through 2035) the total cumulative reduction in emissions could be over 7,000 kilotonnes, the equivalent of 1.5 million passenger vehicles driven for one year.[12]

Potential avoided GHG results are illustrated in Table 5 below.

Table 5: Potential Avoided Green House Gas Emissions

Avoided Green House Gas Emissions (kilotonnes)	
2016 through the end of 2020	1,481
2016 through the end of 2035	7,322

The IESO does not assign avoided costs to reduced GHG emissions, however, a reasonable approximation of the societal benefit of such reduced emissions may be estimated by using the 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 over the first twenty years of the technical potential scenario is approximately $126 million (in 2015 dollars).

Adding this to the figure shown above in Table 4, the present value of the total societal benefit implied by the technical conservation potential of sub-metering is approximately $1.3 billion (see Table 1 above).

[12] United States Environmental Protection Agency Greenhouse Gas Equivalencies Calculator: http://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

2 Introduction

2.1 Background

Enercare 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 individually for the electricity consumed and thus, receives a monthly price signal linking their electricity costs with their electricity consumption. The application of prevailing economic theory suggests that in the face of such a price signal, aggregate multi-residential electricity 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 and savings persistence resulting when units switch from bulk metering to sub-metering, the data used for that 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.

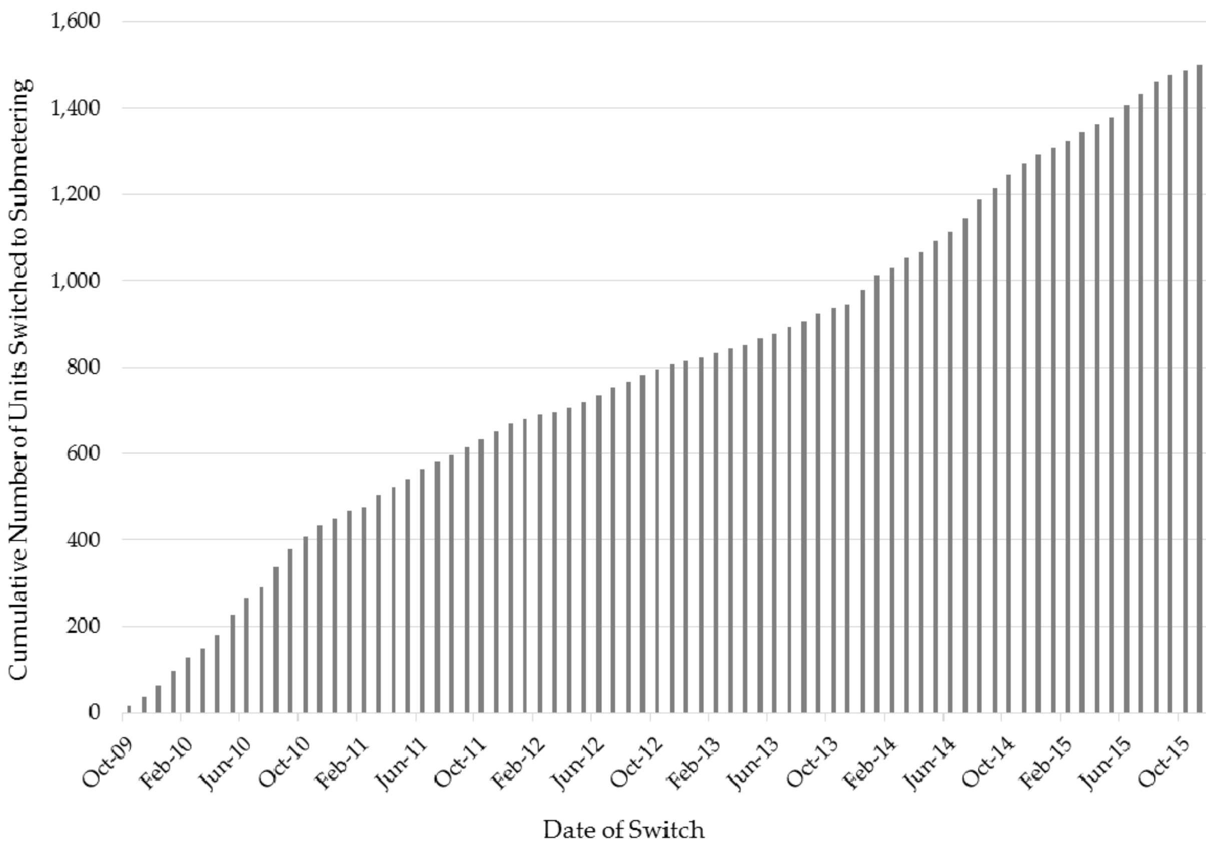
The third part of the report estimates the potential avoided generation, transmission, distribution and GHG emissions cost benefits of such a deployment. Historical avoided GHG emissions are also estimated.

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

3 Sub-metering Conservation Impact

Enercare provided Navigant with the monthly consumption data of 5,137 multi-residential units from September 2009 through to November 2015. Figure 3 illustrates the cumulative number of units in the sample that switch from bulk to sub-metering over the period of analysis. As can be noted from the graph, the transition from bulk to sub-metering is gradual. This is due to the fact that units switch to sub-metering upon a change in tenancy.

Figure 3: Cumulative Number of Units Switching to Sub-Metering



Source: Navigant Analysis

The remainder of this section 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 5,137 apartments in 49 buildings. The dataset is from September 2009 through November 2015. Only data for apartment units that switched from bulk to sub-metering at some point in the sample period 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 number of units that either began on sub-metering or did not switch to sub-metering represents approximately 70% of the units in the dataset. The monthly data include:

   a. Per unit monthly consumption (kWh); and
   b. Indicator for "Bill Payer" (where a Bill Payer indicates a unit subject to sub-metering).

2. Monthly heating and cooling degree days. These were calculated from the monthly average temperature for various weather stations that were found to be the closest to the postal codes of the buildings in the sample, and for which there was the most available data.

To prepare the data for regression analysis, the following data cleaning actions were performed:

- Removal of units that began on sub-metering
- Removal of units that did not switch to sub-metering
- Removal of months where consumption was negative
- Removal of months where consumption was 10 standard deviations from the median usage (to control for outliers)

After removal of the units described above, and after any necessary data cleaning steps, the conservation impact per unit was estimated using 1,500 units from 47 buildings that switched from bulk to sub-metering. Figure 4 below provides a map of the locations of the buildings included in the study. Each blue circle represents the forward sortation area (FSA) in which a building is located (with the size of the circle indicating the density of buildings in that FSA).

Figure 4: Location of Buildings in Study Sample

Source: Navigant Analysis

3.2 *Evaluation Methods*

The impacts and savings persistence were estimated using fixed effects regression analysis applied to unit level consumption panel data for 1,500 units in 47 buildings in Ontario.

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 is a way of controlling for a variety of building characteristics that do not change over time. For example, the number of windows in a unit, the direction it faces or any other characteristic that does not change in any significant way over the period of analysis, but that may be correlated with electricity consumption.

In addition to controlling for individual unit 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.

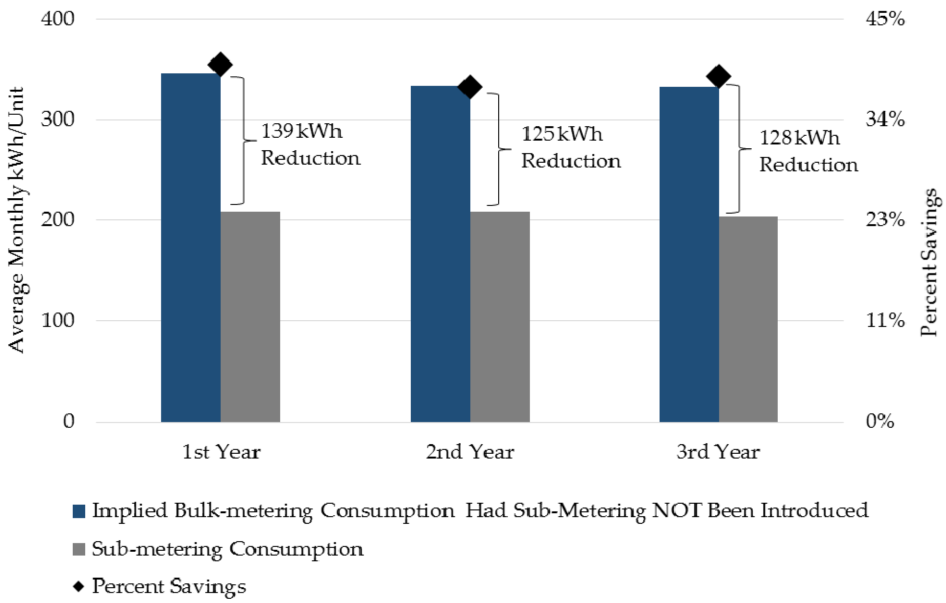
Persistence in savings was estimated through the inclusion of variables that track the length of time each unit had been subject to sub-metering. A detailed description of the model specification used to estimate impacts may be found in the Appendix.

To obtain the overall percentage of electricity savings, Navigant compared the estimated conservation impact (in kWh/unit) to the counterfactual predicted value – what consumption is estimated to have been had sub-metering not been introduced.

3.3 *Conservation Impacts*

As may be seen in Figure 5 below, on average, a switch from bulk to sub-metering is estimated to lead to a 139 kWh per unit (per month) decrease in electricity consumption in the first year of sub-metering. Savings decay slightly in the second year of deployment, falling to 125 kWh/month, but then increase again to 128 kWh in the third year of deployment and persist at this level going forward. These impacts represent a 40%, 37%, and 39% reduction in electricity consumption, respectively. These results represent the average monthly kWh and percentage reduction that is realized when a unit switches from bulk to sub-metering in the first, second, and third years, respectively. Changes in the savings values after the third year of deployment were not found to be statistically significant, indicating that savings in all subsequent years observed in the sample are equivalent to those estimated for the third year of deployment. Navigant is not aware of any conservation program being offered in Ontario or elsewhere that can achieve such high and persistent savings. To put this level of savings into perspective, report-based behavioural programs, such as those offered by OPower and other service providers, typically achieve savings in the range of 2 – 3%.

Figure 5: Average Monthly kWh and Percentage Reduction



Source: Navigant Analysis

The annual reductions that are realized from a switch to sub-metering are shown in Table 6 below. Initial reduction in consumption (Year 1) from a switch to sub-metering results in an annual reduction of 1,664 kWh. A unit subjected to sub-metering for two and three years reduces consumption by 1,501 and 1,542 kWh compared to what would have been consumed under bulk metering, respectively. Estimated savings do not significantly change from the third year value in subsequent years.[13]

Table 6: Annual Estimated Impacts

1st Year	2nd Year	3rd Year	Each Subsequent Year
1,664	1,501	1,542	1,542

[13] Savings in each subsequent year are not statistically different from savings in year three.

4 Provincial Technical Conservation Potential

This section provides an estimate of the aggregate energy and demand savings that could be realized if sub-metering were to be implemented in all applicable multi-residential buildings in Ontario.

The potential savings 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, 2016, sub-metering will be implemented in every building in which it is feasible but not yet present. 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 2016 (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.

Enercare provided Navigant with the estimated number apartment and condominium units in Ontario to which sub-metering might be, but has not yet, been applied.

4.1 *Estimate of Energy Savings*

Navigant has assumed that as of January 1st, 2016, 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-meter billing only with a change of tenancy. Thus, the implicit assumption is that all condominiums are sub-metered for the whole of 2016 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 2020 since the tenancy of rental units is expected to fully "turn-over" in five years. The assumptions above are specific to the analysis under consideration. The following additional assumptions are required for the calculation of technical potential:

1. On average, approximately 20% of rental apartments change tenants each year (as per Enercare internal research).
2. Every time a rental unit changes tenants, beginning in 2016, that unit becomes sub-metered.
3. As of 2016, all condominium buildings are sub-metered.

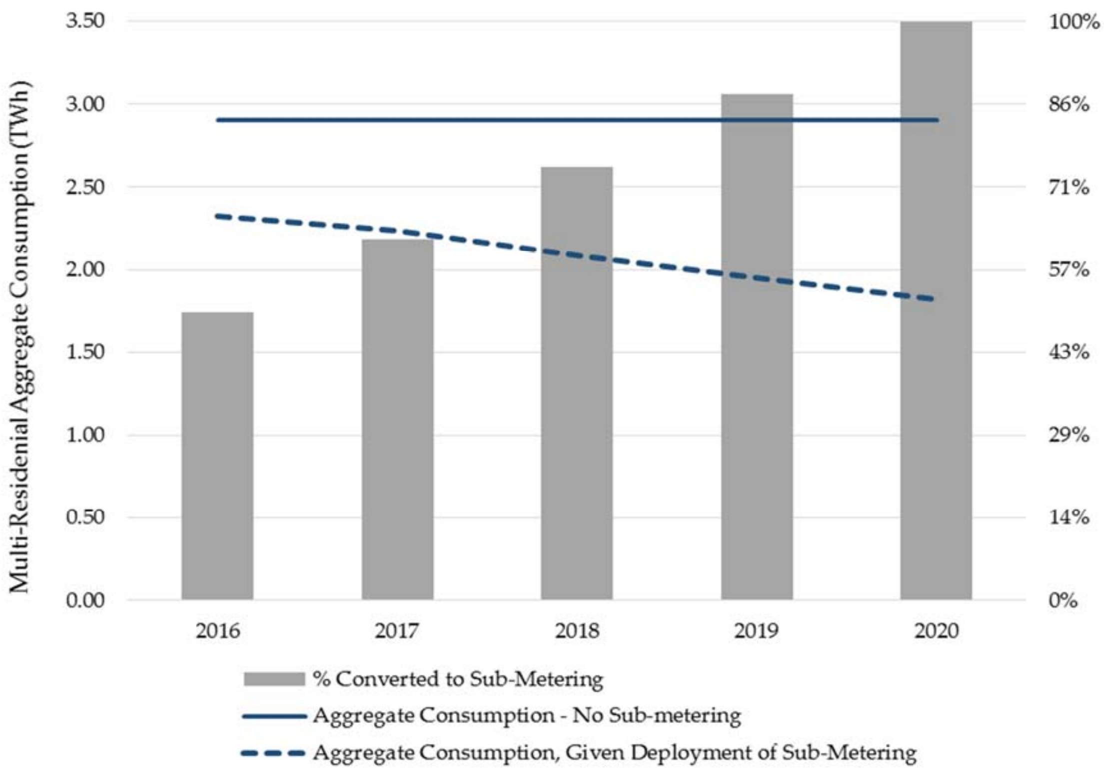
Applying these assumptions to the projected levels of consumption, we obtain a year-by-year estimate of energy (TWh) savings. These are set out in Figure 6 below. In this chart the baseline consumption absent any sub-metering is represented by the solid line, read at the left axis. Aggregate

[14] In this case, sub-metering.

consumption assuming a gradual roll-out of sub-metering for apartments and a one-off roll-out to all condominiums by January 1st, 2016 (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 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 (2016), this is due to all condominium buildings (approximately 40% of the applicable potential energy consumption) switching to sub-metering immediately in 2016. 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 the next four years.

Figure 6: Projected Aggregate Multi-residential Consumption with Sub-Metering

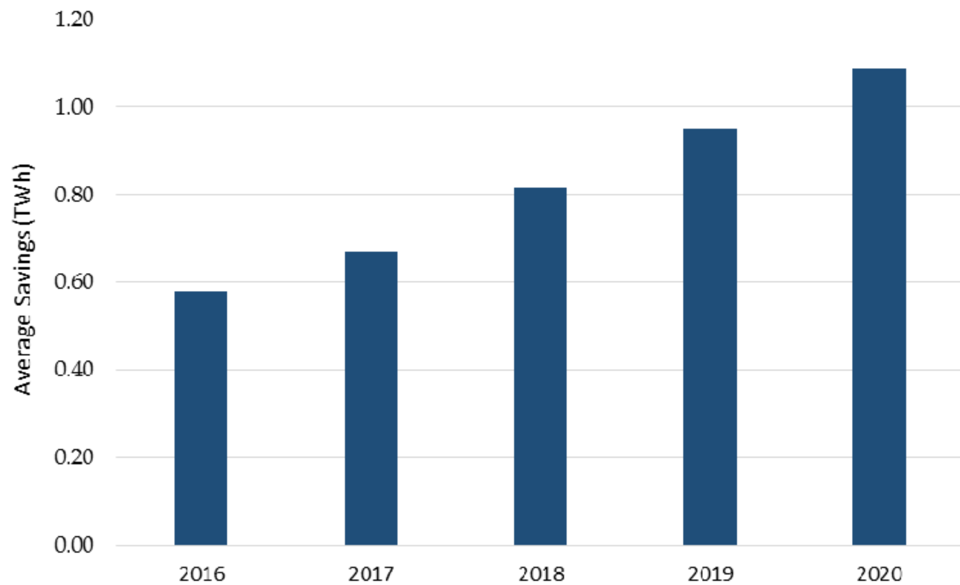


Source: Navigant Analysis

Projected energy savings for each year of the deployment period are shown in Figure 7 below. 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 4.1 TWh. Following this initial roll-out period, potential annual savings could be approximately 1 TWh per year, approximately 5 times the net annual savings of the entire 2014 Consumer Initiatives

Portfolio.[15,16] The total cumulative technical potential over the twenty years from the beginning of 2016 to the end of 2035 could be as much as 20 TWh.

Figure 7: Projected Energy Savings (TWh) – Incremental by Year



Source: Navigant Analysis

4.2 *Estimate of Peak Demand Reduction*

Navigant also estimated the impact on peak demand of sub-metering by applying potential energy savings in 2022 (full deployment) to the peak demand as a percentage of annual kWh developed by the IESO (illustrated in Table 7 below).

Given that the potential annual energy savings by 2022 could be just over 1 TWh, this implies an annual peak demand reduction of 114 MW in the winter and 158 MW in the summer.

Table 7: Peak Demand (as a percentage of annual kWh)

Summer	Winter
0.0146%	0.0105%

[15] Research into Action on behalf of the OPA, *2014 Consumer Program Evaluation Volume 1: Report*, 2015 http://www.powerauthority.on.ca/sites/default/files/conservation/2014-Evaluation-Consumer-Initiatives.pdf

[16] The five consumer energy efficiency initiatives included in the portfolio are: The bi-annual retailer coupons event, the annual coupons initiative, the appliance recycling initiative, appliance exchange imitative, and the heating, ventilation, and conditioning incentives initiative. Net annual savings reflect a net-to-gross ratio.

4.3 *Provincial Avoided Cost and GHG Reduction Benefits*

This section estimates the societal benefits implied by the technical 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 directly included in those tests. In addition, the estimated GHG reductions for units already switched to sub-metering in Enercare's territory is also calculated.

4.4 *Generation, Transmission and Distribution Avoided Costs*

To estimate avoided energy and capacity costs, Navigant applied the estimated potential energy savings in 2022 to a number of IESO end-use load shapes. 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 NRCan Comprehensive Energy Use Database.

The overall eight part load shape is presented in Table 8 below.

Table 8: Multi-Residential 8-part Load Profile

	Winter			Summer			Shoulder	
	Peak	Mid	Off	Peak	Mid	Off	Mid	Off
Multi-Residential	8%	8%	16%	7%	12%	18%	16%	16%

The societal benefits of energy conservation programs are typically quantified through the calculation of the "avoided costs". "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 (2016 through the end of 2020) as well as over the first twenty years of deployment (2016 through the end of 2035), Navigant has used the avoided costs developed by the Ontario Power Authority and included in its Energy Efficiency Resource Planning Tool. Calculation of the avoided costs also makes use of the load profile provided in Table 8 above.

The present value of avoided costs, assuming an inflation rate of 2% and a social discount rate of 4%, is presented in Table 9 below, for the initial five years of technical potential, as sub-metering rolls out across the province. This table also presents the same benefits 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 9 below, the present value of the avoided costs associated with the technical potential estimated, over the first twenty years, would be nearly 1.2 billion dollars.

Table 9: Avoided Cost Benefits of Technical Potential

Avoided Cost Benefit Implied by Technical Potential (Millions, $2015)	
2016 through the end of 2020	$280
2016 through the end of 2035	$1,190

4.5 *Estimate of Greenhouse Gas Emission Reduction*

To calculate the estimated GHG emissions reduction, Navigant has applied a factor of 0.36 tonnes per MWh to estimated historical and potential energy savings. This factor has been obtained by taking the tonnes per MMBtu of carbon dioxide that is produced when natural gas is burned, and multiplying by a heat rate of 6.8 MMBtu/MWh.[17] This value has been chosen because Navigant expects that a CCGT will generally be the marginal generation type in Ontario over the potential 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 this factor to all Enercare units that have been converted to sub-metering between January 2013 and the end of October 2015, Navigant estimates that the historical avoided GHG emissions are over approximately 2.74 kilotonnes.

The total cumulative reduction in greenhouse gas emissions over the roll-out period (2016 through 2020) would be approximately 1,481 kilotonnes. Over the longer 20 year horizon (2016 through 2035) the total cumulative reduction in emissions would be over 7,000 kilotonnes, the equivalent of 1.5 million passenger vehicles driven for one year.[18] These results are summarized in Table 10 below.

Table 10: Avoided Green House Gas Emissions

Avoided Green House Gas Emissions (kilotonnes)	
2016 through the end of 2020	1,481
2016 through the end of 2035	7,322

The IESO does not assign avoided costs to reduced GHG emissions, however, a reasonable 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[19] (both non- and for-profit) to assess the relative quality of these organizations. The highest scoring vendor – Less[20] – offers two types of offset. The Gold Standard-Certified International Offsets

---

[17] Carbon dioxide that is produced when natural gas is emitted obtained from the EIA (note that 1 metric tonne is equal to 2,205 lbs.): https://www.eia.gov/tools/faqs/faq.cfm?id=73&t=11

[18] United States Environmental Protection Agency Greenhouse Gas Equivalencies Calculator: http://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

[19] 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

[20] www.less.ca

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.

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 $126 million.

5 Appendix

5.1 Conservation Impact Analysis

For the analysis presented in this report, Enercare provided Navigant with monthly data for 5,137 multi-residential units from 49 buildings from September 2009 through to November, 2015. To perform the conservation impact analysis, only monthly data for apartment units that switched from bulk metering to sub-metering in the sample period were included. The resulting sample size was 1,500 units across 47 buildings that do not use electricity as the primary fuel for space-heating. 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 is 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 any other building characteristic that does not change in any significant way over the period of analysis, but that may be correlated with electricity consumption. Rather than controlling for each individual characteristic, the analyst applies a fixed effect to each building. This fixed effect controls 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 a dwelling unit. That is, the panel (or longitudinal) data set used to perform the regression contains an observation of consumption for each dwelling unit in each month.

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.

Persistence in savings was estimated through the inclusion of variables that track the length of time each unit had been subject to sub-metering.

Algebraically, the model is presented as:

$$y_{it} = \alpha_i + \gamma_1 Year1_{it} + \gamma_2 Year2_{it} + \gamma_3 Year3_{it} + \beta_j X_{it} + \delta_j Y_t + \varepsilon_{it} \quad (1)$$

Where:

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

α_i = The fixed effect corresponding to building i

$Year1$=A dummy variable equal to 1 when a unit is on sub-metering, and zero otherwise

$Year2$=A dummy variable equal to 1 when a unit has been on sub-metering for longer than 12 months, and zero otherwise (to capture persistence)

$Year3$= A dummy variable equal to 1 when a unit has been on sub-metering for longer than 24 months, and zero otherwise (to capture persistence)

X_{it} = A set of observable variables applicable to unit i in month t. This set includes heating and cooling degree days

Y_t = A set of dummy variables equal to each year (2009 to 2015) of month t to capture annual fixed effects

$\gamma_1, \gamma_2, \gamma_3$ =The parameter estimates for the variables of interest: Year1 conservation impacts, Year2 and Year3 persistence

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

δ_j =The fixed effect corresponding to the year of month t

The parameter estimates corresponding to the variables of interest ($\gamma_1, \gamma_2, \gamma_3$) for the fixed effect model are detailed in Table 11 below.

Table 11: Model Results

Year	Parameter Estimate	Standard Error	p-value	Significance[1]
1st Year	-139	1.74	0.00	**
2nd Year	14	2.08	0.00	**
3rd Year	-3	1.99	0.08	*

[1] **Indicates significance at 5%, * Indicates significance at 10%

From these parameter estimates, we can conclude that a switch to sub-metering, all else being equal, will result in a 139 kWh reduction of electricity consumption in the first year of sub-metering, a 14 kWh increase from 139 kWh in the second year of sub-metering (therefore a total 125 kWh reduction), and a 3 kWh reduction from 125 kWh in the 3rd year (therefore a total 128 kWh reduction).

To obtain the overall percentage electricity savings, Navigant compared the estimated conservation impact (in kWh/unit) to the counterfactual predicted value - what consumption is estimated to have been had sub-metering not been introduced.