Achievable Potential Study: Long Term Analysis

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Principal authors:

Rush Childs, Consultant

Tyler Hammer, Senior Consultant

Henri van Rensburg, Principal

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Representative	Company Name
Mike Marchant	Toronto Hydro
Cory Cook	Toronto Hydro
George Katsuras	Hydro One
Clement Li	Hydro One
Andy Armitage	Thunder Bay Hydro
Kristin Rice	Hydro Ottawa
Stephen Sottile	Utilities Kingston
David Whitehouse	Peterborough Utilities
Matt Weninger	Guelph Hydro
Gary Rains	London Hydro
Sam Ramtahal	Enersource
Steve Zebrowski	Veridian
Weston Sagle	Greater Sudbury Hydro
Sean Perry	Niagara Peninsula Energy
Sorana Lonescu	IESO
Evelyn Lundhild	IESO
Kausar Ashraf	IESO
Nik Schruder	IESO
Bronwen Smith	IESO
Simon Geraghty	IESO
Sumeet Tandon	IESO
Simon Zhang	IESO
Lily Buja-Bijunas	IESO
Hanna Smith	IESO

Representative	Company Name
Musab Qureshi	MOE
Afreen Khan	Electricity Distributors Association
Valerie Bennett	Ontario Energy Board
Charlotte Friel	ECO
John DeVenz	Enbridge Gas

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1 Executive Summary

The achievable potential study is required through a direction from Ontario's Minister of Energy and is a condition of the Energy Conservation Agreement (ECA) between the IESO and Ontario's local distribution companies (LDCs), which governs the 2015 - 2020 Conservation First Framework.

The IESO is required to coordinate, support, and fund the delivery of conservation and demand management (CDM) programs by LDCs to achieve a total of 7 TWh of persisting reductions in electricity consumption between January 1, 2015 and December 31, 2020.

- The potential analysis included both a short term analysis from 2015 to 2020 and a long term analysis from 2015 to 2035. This report addresses the long term analysis, while the short term analysis is addressed in a separate report. The timeframe of the long term analysis is from 2015 to 2035 and the scope includes the following main items:
- Both transmission- and distribution-connected customers; and
- Currently commercially available, as well as new and emerging, technology-based and energy management/behaviour-based energy efficiency measures applicable to the Ontario market[1].

The main outputs of the long term analysis include:

- Annual province-wide and IESO zone-specific achievable cost effective electricity savings and associated costs between 2015 and 2035 under a budget constrained and an unconstrained achievable potential scenario. This output will help to inform the IESO's long term resource planning activities.
- Identification of opportunities and insights for long term conservation program design.
- Analysis to identify most sensitive inputs to the results.
- Development of long-term cost curves.
- Recommendations to direct future work.

[1] Behind-the-meter-generation or embedded load displacement, demand response, and pricing mechanisms will not be included as eligible measures. The potential savings from eligible behind-the-meter generation will be analyzed in a separate study.

Measures

A list of energy efficiency measures were developed and researched. A workbook was developed for each measure and the number of measures per sector is:

- 138 measures for residential sector
- 219 measures for commercial sector
- 188 measures for industrial sector

The list of all the measures is included in an Excel workbook, which accompanies this report and includes for each measure:

- Name of measure
- Measure type
- Baseline technology
- Applicable end use

IESO Zone Profiles

One of the main objectives of the achievable potential study is to develop the potential from the bottom-up for each LDC and IESO zone. In the short term analysis, unique profiles were developed for each LDC, along with an estimate of their savings potential. These profiles define the LDC's customer segmentation and its energy use by sector and subsector. The bottom-up analysis approach captures market differences between LDCs and provides an energy efficiency potential that is a more accurate reflection of the opportunities within each specific LDC when compared to top-down approach. The development of these profiles is described in the report for the short term analysis. The LDC profiles informed the development of the IESO zone profiles, which define the customer segmentation and energy use by sector and subsector for each of the ten IESO zone.

As part of the LDC load profile development, the availability of natural gas to residential customers in each of the 75 LDC service territories was researched. The LDC profiles were also segmented by mapping the LDCs to IESO zone and to a climate region. The climate regions were based on International Climate Zones from ASHRAE Standard 90.1-2007. Ontario includes Climate Zones 5, 6 and 7. Since Hydro One customers are located across the province, a weighted average approach was applied in the development of Hydro One's segmentation and load profiles.

Nexant consulted with IESO and its stakeholders to understand how projected customer composition is incorporated into each LDC's energy forecast. LDC load forecasts were adjusted to capture annual changes in total customers and customer mix that are expected to occur between 2015 and 2035.

Base Year and Reference Case Forecast

In the 2014 base year, the largest portion of electricity was consumed by the commercial sector (57,279 GWh/year or 43% of the total electricity use), while the residential sector (39,461 GWh) and the industrial sector (36,282 GWh) each accounts respectively for 30% and 27% of the total electricity use in 2014. The residential single family subsector accounts for the largest electricity use by subsector with 29,974 GWh/year. The end use with the largest electricity use is general interior lighting in the commercial sector with 15,964 GWh/year.

When compared to the 2014 base year, the load forecast for 2015 to 2035 estimates a total increase in electricity use of 11% from 133,022 GWh in 2014 to 147,147 GWh in 2035. The commercial sector is expected to provide the largest increase in electricity use, growing by 18% to 10,218 GWh by 2035. Residential sector electricity use is expected to decrease by 5% to 37,632 GWh in 2035, while industrial sector electricity use is expected to increase by 16% to 42,017 GWh in 2035. In absolute terms, the largest decrease in electricity consumption by subsector is expected to occur in the residential single family and industrial paper and primary metals manufacturing subsectors. The largest increases in electricity by subsectors are expected to occur in most of the commercial subsectors and in the industrial chemicals manufacturing and mining subsectors.

Savings Potential

The persistent savings in 2035, range from 53% for the technical potential to 12% for the budget constrained achievable potential when compared to the reference case forecast. The largest portion of the savings in the budget constrained achievable potential is from the commercial sector, which accounts for 78% of the savings, while the residential sector accounts for 12%, as illustrated in Figure 1-2.

Figure 1-1 Potential Scenarios Compared with Reference Case

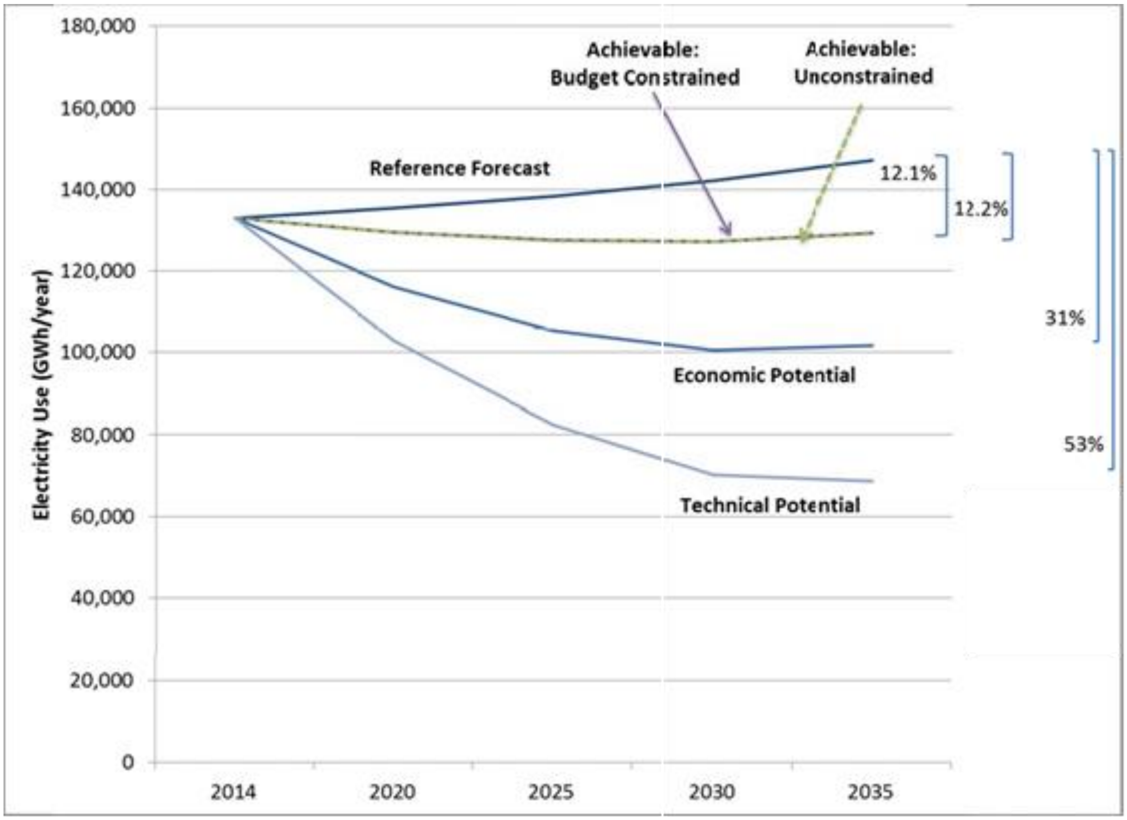
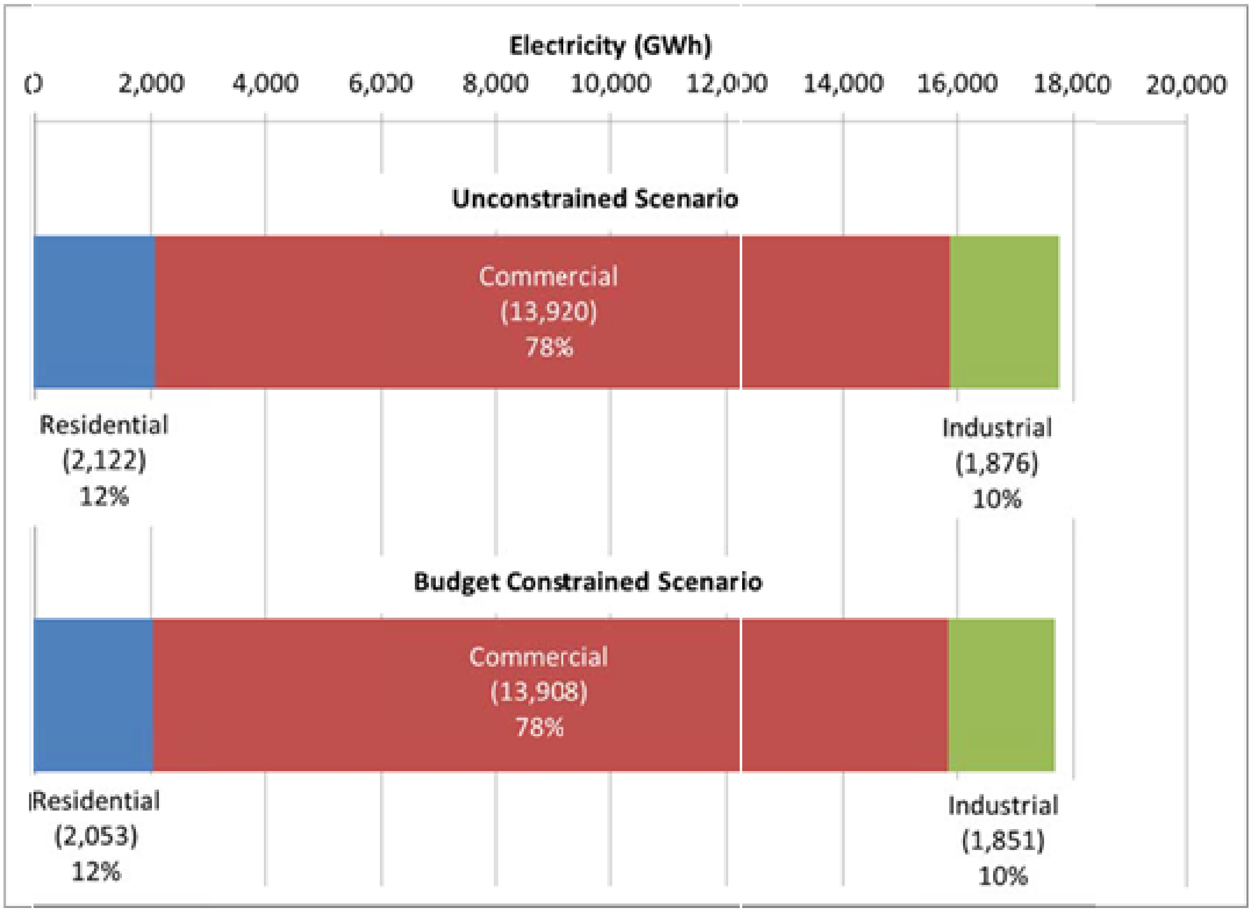


Table 1-1: Annual Electricity Use by Scenario for 2014 to 2035 (GWh/year)

Scenario	2014	2015	2020	2025	2030	2035
Base Year and Reference Case	133,022	130,329	135,562	138,328	142,129	147,147
Achievable Potential: Budget Constrained	133,022	129,708	129,575	127,523	127,282	129,336
Achievable Potential: Unconstrained	133,022	129,696	129,516	127,436	127,181	129,229
Economic Potential	133,022	126,983	116,081	105,338	100,451	101,633
Technical Potential	133,022	124,609	102,816	82,530	70,185	68,565

Figure 1-2: Achievable Potential Persistent Savings by Sector in 2035



When comparing the TRC and PAC for the achievable potential scenarios, the commercial and industrial sectors are revealed as relatively more cost effective than the residential sector. The TRC for the commercial sector is 3.6, compared to 1.7 for the industrial sector and 2.7 for the residential sector.

The portfolio acquisition cost in 2035 is estimated to be $ 308 / MWh[2] for the budget constrained scenario. In the budget constrained scenario, the commercial sector has the lowest acquisition cost at $ 208 / MWh, while the residential sector has the highest acquisition cost at $ 961 / MWh.

[2] All cost values are based on net present value calculations.

Additional Analyses

Sensitivity Analysis

The objective of the sensitivity analysis is to assess the impact on the achievable potential savings if key input parameters are changed. The following parameters were assessed:

- Incentive rates
- Adoption curves
- Avoided cost

The budget constrained scenario indicates that the portion of residential load affects the impact of increasing or decreasing the incentive rates. Due to the lower price elasticity for the residential sector, for an LDC with a relatively larger portion of residential load, the more money that is allocated to incentives does not result in incrementally more savings.

For both unconstrained and budget constrained scenarios the increase or decrease in savings are relatively proportional to the changes in adoption rates. Increased adoption rates in the budget constrained scenario do have a significantly lower impact on increased savings compared to the unconstrained scenario. A 25% increase in adoption rates result in an increase in savings of between 6% and 8% in the budget constrained achievable potential scenario, compared to 23% to 24% for the unconstrained achievable potential scenario.

A small correlated impact is observed for the unconstrained potential, where a 25% increase in avoided costs leads to a small amount of additional potential of about 3%. The sensitivity analysis indicates that the residential sector is more sensitive to changes in avoided costs. For the budget constrained achievable potential scenario, there doesn't seem to be any direct correlation with an increase or decrease of avoided cost.

Behind-the-Meter Generation

The potential for electricity reduction resulting from behind-the-meter generation (BMG) was assessed in a separate study and the methodology and results are presented in a separate report published by IESO. The results from the BMG study were used to determine the total achievable potential for electricity reduction. The total budget constrained achievable potential for EE and BMG is estimated to be 19,390 GWh in 2035 and the budget associated with the achievable potential is $ 5,783 million.

Recommendations

Since the long term analysis was built from the bottom up, using the short term analysis as a foundation, the recommendations are aligned with the short term analysis. With input from IESO and the Working Group, recommendations were identified to improve data, accuracy, address gaps an enhance the process for future potential analyses. The full list of recommendations is provided in the report for the short term analysis and only the items of specific relevance to the long term analysis are summarized in the table below.

Table 1-2 Observations and Recommendations

Overall Process, Methodology and Schedule
Sufficient time needs to be allocated to generate and review draft results. It is recommended to conduct test model runs to review draft results prior to undertaking a full model run.
Methodologies and approaches were reviewed and adjusted as needed throughout the study. In future studies it may be beneficial to identify key methodologies and plan extra time for review of these methodologies and their implications.
The study used an optimized TRC ranking approach to estimate the budget constrained achievable potential. Depending on the objectives of future potential studies it may be beneficial to review additional approaches to develop budget constrained achievable potential.
This was the first time that both EE and BMG potential was assessed and integrated to derive the potential savings. Combining the two studies into one study will assist in a more effective alignment of the methodologies and schedule of the integration.
The study was completed in mid-2016 and used 2014 as the base year, but close to the completion of the project, program evaluation data became available for 2015. It is recommended to consider the timing of the program evaluation results when scheduling the achievable potential study and when selecting the base year

Data Collection
Since the study followed a bottom-up approach that was LDC and program focused, it is important to obtain as much LDC and program primary data as possible.
Obtaining LDC data prior to the formal kick-off of the study assisted in optimizing the time required to conduct the study and it is recommended to follow a similar approach for future studies.
Program performance data provides important input for the study, especially in terms of understanding participation rates and measure take up. Accurately tracking this information and being able to access the information for the study, will help to increase the accuracy of future studies.

Data Collection
It is recommended that IESO identify internal program data at the measure level that can be leveraged for future potential studies

Measure
The incentive rate is a significant driver in the acquisition costs (typically representing the majority of the program delivery costs). While fairly good records are kept on the incentive costs, information on the average measure incremental costs was not as well organized. A province-wide database that tracks measure incremental costs would be useful for the accurate estimation of incentive rates. The IESO's M&A list and measure database are important information sources for the achievable potential studies. It is recommended to expand the measure database to address: baseline information, incremental cost data, 8760 avoided energy cost and deemed savings and costs for key parameters.

Coordination with Natural Gas DSM Programs
A few measures are applicable to both CDM and DSM programs. It is recommended to share data relevant to the take up of these measures to inform future potential studies. The shared data can also assist in program design and program delivery to minimize duplication of efforts between LDCs and the gas utilities.

2 Introduction

The achievable potential study is a requirement of a direction from Ontario's Minister of Energy and a condition of the Energy Conservation Agreement between the IESO and Ontario's local distribution companies (LDCs), which governs the 2015 - 2020 Conservation First Framework.

The IESO is require to coordinate, support and fund the delivery of conservation and demand management (CDM) programs by LDCs to achieve a total of 7 TWh of persisting reductions in electricity consumption between January 1, 2015 and December 31, 2020.

There are two major needs for developing a new estimate of the achievable electricity conservation potential in Ontario:

- Develop an estimate of LDC-specific and province-wide (LDC-aggregate) achievable potential between 2015 and 2020 to inform the mid-term review of the 2015- 2020 Conservation First Framework and to provide insights to assist LDCs with program planning and design. This is referred to as the *short term analysis*.
- Develop a 20 year provincial achievable potential forecast to inform long term resource planning and energy efficiency program design. This is referred to as the *long term analysis*.

Nexant was retained by IESO to undertake the APS and to deliver results and reports for the two analyses. This report addresses the long term analysis, while the short term analysis is addressed in a separate report. The timeframe of the long term analysis is from 2015 to 2035 and the scope includes the following main items:

- Both transmission- and distribution-connected customers; and
- Currently commercially available, as well as new and emerging, technology-based and energy management/behaviour-based energy efficiency measures applicable to the Ontario market[3].

[3] Behind-the-meter-generation or embedded load displacement, demand response, and pricing mechanisms will not be included as eligible measures. The potential savings from eligible behind-the-meter generation will be analyzed in a separate study.

The main outputs of the long term analysis include:

- Annual province-wide and IESO zone-specific achievable cost effective electricity savings and associated costs between 2015 and 2035 under a budget constrained and an unconstrained achievable potential scenario. This output will assist to inform the IESO's long term resource planning.
- Identification of opportunities and insights for long term conservation program design.
- Analysis to identify most sensitive inputs to the results.
- Development of long-term cost curves.
- Recommendations to direct future work.

3 Methodology

To conduct the long term analysis, Nexant built upon the data inputs, participation estimates, and measure energy savings estimates from the short term analysis. However, for the long term analysis, savings and costs were modeled by IESO zone rather than by LDC. Findings are reported by sector, subsector, and by end use for each of the ten IESO zones and reported for the 2015, 2020, 2025, 2030 and 2035 time horizons. Nexant loaded the achievable potential findings into a dynamic cost curve tool, provided in an Excel workbook format to IESO, to inform long term resource planning decisions. Details on the approach undertaken to conduct the long term analysis are provided below.

The study's approach relied on best practices[4] in potential analysis as well as collaboration and transparency between Nexant, IESO and its stakeholders. Nexant shared all major analysis spreadsheets and assumptions with IESO and the Working Group. Table 3-1provides a summary of tasks for the long term analysis and the associated report sections where the methodology, results and discussions are presented. In each of the report sections the associated methodology is described at the beginning of the section.

One of the main objectives of the long term analysis is to provide input to IESO's long term planning, which uses the End Use Forecaster (EUF) model. To ensure the data and results from the long term analysis of the achievable potential study can be used by the EUF model, the methodology of the long term analysis is structured to develop an economic potential with Nexant's model that is aligned with assumptions used by the EUF model. Inputs and outputs from Nexant's mode will be mapped in alignment with the EUF model, to enable the use of data and results in the EUF model. The results of the two models will be compared to inform justification of differences and/or to make adjustments to the two models as appropriate.

[4] The best practices were based on Nexant's experience conducting more than 35 potential studies, Nexant's familiarity with potential studies conducted by other consultants and input provided by the Expert Panel

Table 3-1 Tasks and Associated Report Sections

Task	Report Section Presenting Methodology / Result / Discussion
Task 1: Refine measures	Section 4
Task 2: Develop IESO zone profiles and forecast disaggregated load	Section 5 and 6
Task 3: Estimate economic potential	Section 8
Task 4: Bundle cost-effective measures and map to subsectors and end uses	Section 7
Task 5: Estimate achievable long term potential	Section 9
Task 6: Results analysis	Section 10
Task 7: Develop report and deliverables	Section 3

Detailed methodologies, together with the results and analysis, are presented for each step in the potential analysis process within the respective report sections (listed below):

- Measures
- IESO zone profiles
- Base year and reference case forecast
- Technical potential
- Economic potential
- Achievable potential
- Additional analyses
- Conclusions and recommendations

4 Measures

An important research task of the potential study is a review of energy efficiency measures. The objective of the research is to develop a comprehensive list of measures applicable to Ontario, which includes both technology and non-technology measures. The research obtained information about measures, such as: savings, costs, and measure lifetimes. The information from this research provided the necessary input to assess the potential savings in the technical, economic and achievable potential scenarios.

4.1 Methodology

Measures included in IESO's Measure and Assumption (M&A) list formed the basis for the measure research and was used to populate an initial measure list. This list was supplemented with Nexant's internal extensive measure library and measures from other Technical Reference Manuals (TRMs) in North America. The short term analysis included only commercially available measures in Ontario, while research for the long term analysis included measures that are under development and are expected to become commercially available during the next 20 years. Once a draft set of energy efficiency measures was compiled, it was reviewed with the IESO before the list was finalized. Once the energy efficiency measure list was finalized, the potential measure impacts were determined by collecting data on energy savings, costs, lifetimes, and technical applicability. This work involved a five step process.

1. Define market classes and develop end use, subsector and sector profiles.
2. Screen measure eligibility and applicability.
3. Develop base case measure consumption and costs.
4. Develop efficient case measure impacts and costs.
5. Collaborate with IESO and APS working group for the short term analysis to gather measure feedback and refine parameters.

The methodology includes an assessment of measures in terms of cost effectiveness, competition and interactive effects. Further details on the research and methodology applied in the five steps are provided below.

Step 1: Define Market Classes and Develop End Use, Subsector and Sector Profiles

Each measure was defined according to its applicability to: sector, subsector, end use, climate region, and vintage (for example existing buildings or new construction). Table 4-1 summarizes the sectors and subsectors used in the study, which were aligned with the IESO's End Use Forecasting (EUF) model for long-term planning purposes.

To align the measures with end uses, subsectors and sectors, it was necessary to develop end use profiles for each subsector and sector. These profiles also provided the framework for the subsequent modelling of saving potential.

Table 4-1: Sectors and Subsectors

Sector	Residential	Commercial	Industrial
Subsector	Single family Row house Multi-unit Residential Building (MURB) low rise Multi-unit Residential Building (MURB) high rise Other Residential	Large office Small office Non-food retail Food retail Restaurant Lodging Hospitals Nursing homes Schools Universities Warehouse wholesale Data centers TCU (Transportation / Communication / Utilities) Other commercial buildings	Primary metals Paper manufacturing Auto parts manufacturing Chemical manufacturing Plastic and rubber manufacturing Food and beverage manufacturing Fabricated metals Non-metallic minerals Wood products manufacturing Petroleum refineries Electronics manufacturing Mining Agriculture Miscellaneous industrial

End use profiles were developed by climate region for each subsector to provide a profile template of energy end use. End use profiles from the IESO's End Use Forecaster (EUF) model were used and an example is provided in Figure 4-1 for the single family subsector, indicating that the profile consists of the contribution of each end use to the total energy use (i.e. 100%) of the subsector.

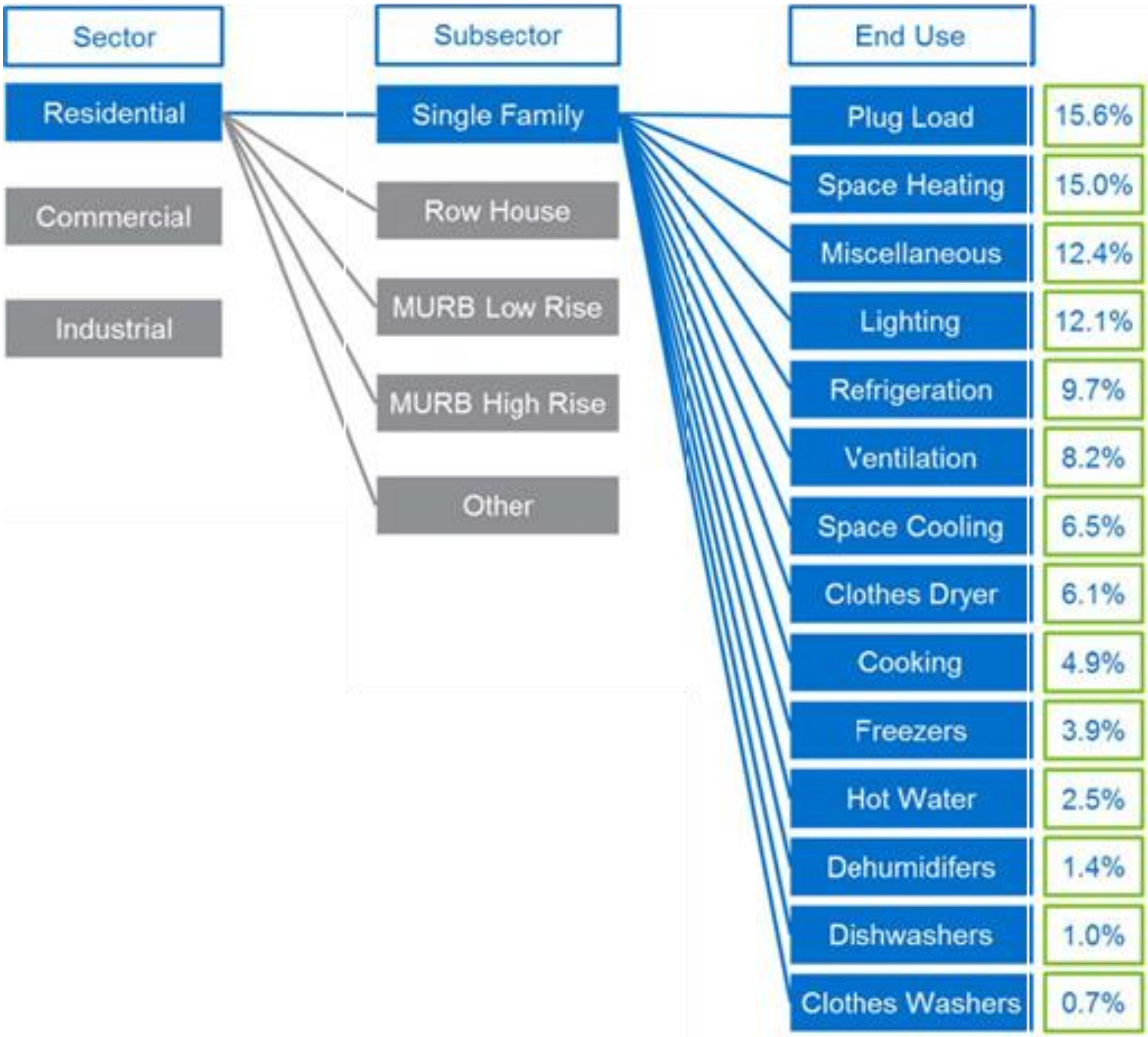
Step 2: Screen Measure Eligibility and Applicability

Measures were screened to ensure only measures that are eligible, as per the Conservation First Framework requirements, are included in the measure list. Measures were also screened to ensure only measures applicable to Ontario were included.

Step 3: Develop Base Case Measure Consumption and Costs

Each measure provides an energy savings compared to a base case equipment or measure. The base case equipment or measure was determined along with its annual energy consumption and efficiency. A description of all base case equipment, efficiencies, and practices were documented. Information to determine annual energy consumption was obtained as part of the development of the LDC profiles, which is described in the report for the short term analysis.

Figure 4-1: Example of End User Profile



Step 4: Develop Efficient Case Measure Impacts and Costs

For each of the energy efficiency measures, savings and cost impacts were determined. Savings and cost data are necessary to determine cost effectiveness of measures and programs. In general, the cost of a replacement measure is based on the incremental cost, while the cost of a retrofit measure is the full measure cost. The main sources of information were IESO's M&A list, Nexant's measure library, Technical Reference Manuals (TRMs), measure databases across North America, and research that includes cost databases (such as RSMeans) and vendor data.

For both measure costs and base case consumption, Nexant also accounted for the varying measure vintage permutations of turnover (i.e. replace on burnout), early replacement, new construction and existing (i.e. retrofit). Depending on the vintage permutation for each measure, the assumed base case consumption was aligned with either code minimum or market baseline (i.e. base line of existing stock of equipment), while the assumed measure cost was either the incremental cost of the measure over the baseline or the full cost of the measure. Table 4-2 below shows the varying baseline/cost assumptions Nexant used in the measure research.

Table 4-2: Measuring Vintage Table

Measure Type	Vintage	Description	Savings Baseline	Cost
Equipment	Turnover	Replace equipment at end of life	Code	Incremental Cost
	Early Replacement	Replace equipment before end of life	Existing Stock	Full Cost
	New	Install equipment in new construction	Code	Incremental Cost
Non-Equipment	Existing	Retrofit existing condition (e.g. add insulation)	Existing Stock	Full Cost
	New	Install measure in new construction	Code	Incremental Cost

Step 5: Collaborate with IESO to Gather Measure Feedback and Refine Parameters

The measure assumptions and data were reviewed with IESO staff prior to finalizing the measure workbooks and inputs for the model.

4.2 Measures

The complete measure lists include:

- 138 measures for residential sector
- 219 measures for commercial sector
- 188 measures for industrial sector

The list of all the measures is included in an Excel workbook, which accompanies this report and includes for each measure:

- Name of measure
- Measure type
- Baseline technology
- Applicable end use

A sample of the measure list is provided in Table 4-3.

For each measure, a workbook was developed, which included the following information:

- Classification of measure by type, end use and subsector
- Measure life
- Description of base case and primary and secondary efficiency cases

- Variable inputs
- Savings algorithms and calculations per subsector, taking weather zones and subsectors into consideration
- Cost algorithms and calculations
- Sources and supporting information
- Output to be used as input in Nexant's potential analysis model

An example of a measure workbook is provided in Figure 4-2, Figure 4-3, and Figure 4-4.

Table 4-3: Sample of Measure List for Residential Sector

Measure Name	Measure Type	Base Technology	End Use
Residential New Construction Tier 1 (10% more efficient)	Non-equipment	Standard residential new construction building	All
Residential New Construction Tier 2 (20% more efficient)	Non-equipment	Standard residential new construction building	All
Residential New Construction Tier 3 (30% more efficient)	Non-equipment	Standard residential new construction building	All
Behaviour Modification: Home Energy Reports	Non-equipment	No report provided to customer	All
Clotheslines	Non-equipment	Clothes Dryer (141 loads/yr)	Clothes Dryers
ENERGY STAR Dryers	Equipment	Standard Dryer	Clothes Dryers
Clothes Washers CEE Tier 1/ ENERGY STAR	Equipment	Standard Clothes Washer	Clothes Washers
Clothes Washers CEE Tier 2	Equipment	Standard Clothes Washer	Clothes Washers

Measure Name	Measure Type	Base Technology	End Use
Clothes Washers CEE Tier 3	Equipment	Standard Clothes Washer	Clothes Washers
ENERGY STAR® Dehumidifier - Replace With New	Equipment	Non-Energy Star® Dehumidifier	Dehumidifiers
ENERGY STAR Dishwashers (Electric Water Heating)	Equipment	Standard dishwasher	Dishwashers

Figure 4-2: Example of Measure Workbook - Classification

Summary Table	Fields
Name	ECM MOTORS FOR HVAC APPLICATION (FAN-POWERED VAV BOX) - VAV Units
Number	34
Sector	Industrial
End Use	HVAC
Type	Equipment
Equipment Type 1	HVAC
Equipment Type 2	
Equipment Type 3	
Equipment Type 4	
Equipment Type 5	
Competition Group	
Efficient Case Description	ECM Motor on VAV Fan,1/15 HP
Primary Base Case Description	PSC motor on VAV Fan, 1/15 HP
Secondary Base Case Description	PSC motor on VAV Fan, 1/15 HP
Tertiary Base Case Description	n/a
Codes, Standards, & Regulations	
Measure Unit	Per Unit
Premise Unit	Per Building
Savings Units	kWh
Measure Life (yrs)	15
Estimated Measure Savings Impact	High
Notes	

Figure 4-3: Example of Measure Workbook - Inputs, Savings and Sources

Inputs

Category	Parameter	Attribute	Units	Source
Variable Inputs	ECM motor power (Wattsee)	75	Watts	2015 PA TRM Page 315
	SP motor power (Watts-sp-base)	120	Watts	2015 PA TRM Page 315
	Load Factor	0.9	%	2015 PA TRM Page 314
	Demand Interactive Factor (IFkW)	0.3	%	2015 PA TRM Page 314
	CF	0.99	unitless	2011 quasi-prescriptive release v1, table 3, pg 324, CF2, summer
	SESP	42.0%		2011 quasi-prescriptive release v1, table 2, pg 323, com space cooling, summer peak
	Hperiod	528	hours	2011 quasi-prescriptive release v1, table 1, pg 322, summer peak hours
Global Inputs (automatically loaded)	Segment 1	Primary Metals		
	Segment 2	Paper Mfg		
	Segment 3	Auto Parts Manufacturing		
	Segment 4	Chemical Mfg		
	Segment 5	Plastic And Rubber Mfg		
	Segment 6	Food And Beverage		
	Segment 7	Fabricated Metals		
	Segment 8	Non Metallic Minerals		
	Segment 9	Wood Products		
	Segment 10	Petroleum Refineries		
	Segment 11	Mining		
	Segment 12	Miscellaneous Industrial		
	Segment 13	Agricultural		
	Segment 14	Electronic Manufacturing		
Conversion Factors	W per kW	1,000		

Savings Algorithms & Calculations

Algorithms (from 2014 Pennsylvania TRM)

Delta kWh = kWhbase - kWhee

kWhee= ((Wattsee/1000) x LF x EFLHcool x (1+IFkwh))

kWhbase= ((Wattsbasee/1000) x LF x EFLHcool x (1+IFkwh))

Ifkwh = Ifkw x (1-(EFLHheat/(EFLHheat + EFLHcool)) x 13/11.3

2011 Quasi-Prescriptive Release v1, Appendix A, pg 323

Average demand savings (ΔP_{AVG}) is estimated as follows:

$$\Delta P_{AVG} = \frac{\text{AES (kWh)} \times \text{\% SESP}}{H_{PERIOD}}$$

where:

AES (kWh) Annual energy savings

Figure 4-4: Example of Measure Workbook - Costs

Costs Algorithms & Calculations

Algorithms

	Turnover	Early Replacement	New
ECM MOTORS FOR HVAC APPLICATION (FAN-POWERED VAV BOX) - VAV Units	$134	$262	$134

Supporting Documents

1	
Baseline Cost	
$127.83	Grainger Industrial Supplies Cost Data
2	
Efficient Case Cost	
$262.23	Grainger Industrial Supplies Cost Data

5 IESO Zone Profiles

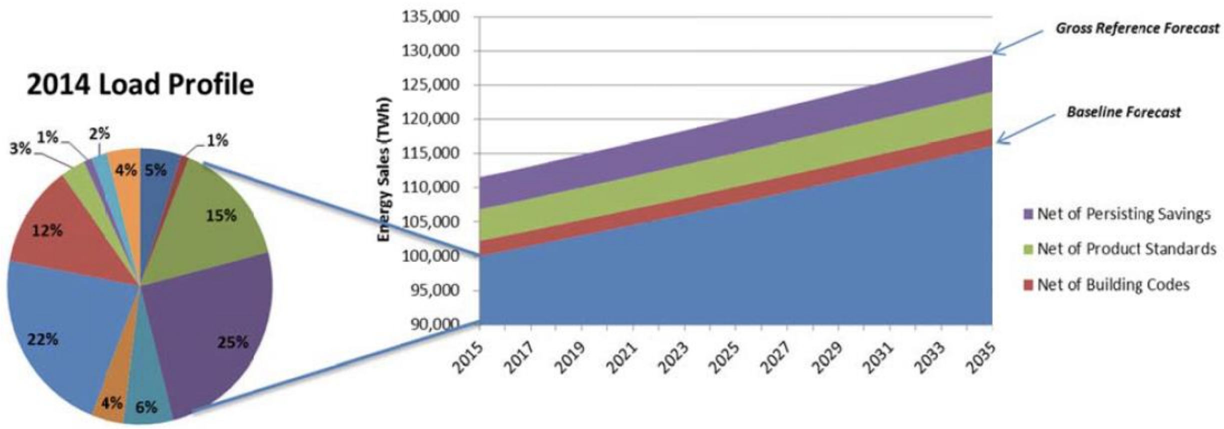
One of the main objectives of the achievable potential study is to develop the potential from the bottom-up for each LDC and IESO zone. In the short term analysis, savings potential was estimated for each LDC, and unique profiles were developed for each LDC. These profiles define the LDC's customer segmentation and its energy use by sector and subsector. The bottom-up analysis approach captures market differences between LDCs and provides an energy efficiency potential that i a more accurate reflection of the opportunities within each specific LDC when compared to top-down approach. The development of these profiles is described in the report for the short term analysis. These LDC profiles informed the development of the IESO zone profiles, which define the customer segmentation and energy use by sector and subsector for each IESO zone. This section describes the methodology of how the IESO zone profiles were developed, provides an example of a profile and provides recommendations for future studies.

5.1 Methodology

The objective of this task was to develop load profiles that identify the share of the electricity load by sector, by subsector and by end use by year for each of the ten IESO zones. These load profiles were built from the LDC load profiles developed for the short term analysis using a similar bottom-up approach, and it was compared against the EUF model reference end use forecast. Adjustments were made to the IESO Zone forecasts where needed to ensure the two forecasts are in general alignment.

Since the aim of the long term analysis is to estimate achievable potential at the province and IESO zone level (as opposed to for the LDC level), Nexant developed ten load profile forecasts (energy sales by sector, by subsector, and by end use) that align with the ten IESO zones used in the EUF model for long term planning in the steps as outlined below. Figure 5-1 shows a simplified example of how the reference load forecast was established for each IESO Zone.

Figure 5-1: Simplified Illustration of Baseline Load Forecast Development by IESO Zone



1. Disaggregate Base Year Load by Sector/Subsector: To disaggregate the base year load by sector/subsector and develop the ten IESO zone profiles for the long term analysis, Nexant drew on the work completed as part of the short term analysis to develop the LDC Profiles. Each LDC was mapped to an IESO zone(s) to allocate and sum up the necessary baseline year (2014) energy load and customers by sector and subsector within each zone5. Table 5-1 provides a summary of the subsectors that are defined for the study.

2. Add in Transmission-Connected Customers: Nexant added in transmission connected customers and energy load for each of the applicable IESO zones, and mapped the customer accounts to the appropriate subsector to ensure the top-line 2014 load represents the eligible population for the long term analysis.

3. Compare with EUF Model: The distribution of sales by sector and subsector as summed up by IESO Zone from each LDC load profile was compared with the distribution of sales by sector and subsector from the EUF model. Based on the comparison it was deemed appropriate to use the end use profiles (in percentage terms) from the EUF model, along with sub-sector load allocation profiles developed from the LDC profiles.

[5] Where LDC service territories cross multiple IESO zones, Nexant estimated the share of each LDC's load and customers that resides in each IESO zone. Respective shares of their load and customers were allocated to the appropriate IESO zone, with the distribution of load and customers by subsector and end use for that LDC remaining constant across IESO zones

Table 5-1: Sectors and Subsectors

Sector	Residential	Commercial	Industrial
Subsector	Single family Row house Multi-unit Residential Building (MURB) low rise Multi-unit Residential Building (MURB) high rise Other Residential	Large office Small office Non-food retail Food retail Restaurant Lodging Hospitals Nursing homes Schools Universities Warehouse wholesale Data centers TCU (Transportation / Communication / Utilities) Other commercial buildings	Primary metals Paper manufacturing Auto parts manufacturing Chemical manufacturing Plastic and rubber manufacturing Food and beverage manufacturing Fabricated metals Non-metallic minerals Wood products manufacturing Petroleum refineries Electronics manufacturing Mining Agriculture Miscellaneous industrial

4. Disaggregate Base Year Load by End Use: Each of the ten IESO zone subsector load profiles was disaggregated by end use for the 2014 baseline year. Various secondary sources were analyzed, such as Ontario and Canada benchmarking studies, and U.S. Energy Information Agency (EIA) energy use profile studies, and it was concluded that the EUF model end use load profiles were the most appropriate end use load profiles to be used.

5. Apply Base Year Load Profiles to IESO Zone Base Year Top-Line Gross Sales: Nexant applied the ten 2014 base year load profiles (energy sales distribution percentages by sector, by subsector, by end use) to the top-line IESO zone energy sales for the base year (2014).

6. Apply IESO's Net Reference Forecast: Nexant applied the IESO sector and sub- sector drivers to develop a net reference forecast (2015 to 2035) consistent with the IESO EUF model's net reference forecast.

The IESO net forecast is a result of removing the impact of anticipated changes in building codes (e.g. HVAC and lighting) and more efficient product standards (e.g. appliances), as well as influences of other programs and persistent savings from programs delivered up until 2014. Subtracting these codes and standards, and persistent savings from IESO's gross forecast provides the net reference forecast, which is defined as the reference forecast for this study.

7. Adjust End Use and Subsector Load Shares by Year (as appropriate): To account for changes to the end use and customer subsector mix over time, compound annual growth rates (CAGR) for end use energy intensity estimates from the EUF reference forecast were reviewed and applied to the base year IESO Zone load profiles so that changes in the end use shares of energy load over time can be captured.

By properly accounting for these factors, the study estimated the electricity use from 2015 to 2035, in the absence of the impact from CDM programs and persistence of savings from programs delivered prior to 2015, standards and codes and other conservation programs.

5.1.1 Segment LDC Customers by Access to Natural Gas

As part of the LDC load profile development in the short term analysis, the availability of natural gas to residential customers in each of the 75 LDC service territories was researched. This is important because the customers with access to natural gas tend to have gas-fueled space heating equipment, which significantly reduces their electricity load when compared with customers who use electrically-fueled space heating equipment. Data was used from the MPAC database, which identified the counts of space heating equipment and their fuel-type within each LDC service territory. These counts were used to calculate an electric space heat saturation value (i.e. the percentage of homes that use electrically fueled equipment to heat their homes).

The LDCs were grouped into three categori s to identify their service territories as either having low, moderate or high saturations of electric space heat (see table below). These categories were used to adjust the researched average household space heating electric energy consumption within ach subsector up or down. LDCs with high electric heat saturation had their space heating consumption adjusted up, while LDCs with low electric heat saturation had their space heating consumption adjusted down.

5.1.2 Segment LDC Customers by Climate Region

As part of the short term analysis, the LDC profiles were further segmented by mapping the LDCs to a climate region. This enabled the identification of variances in measure savings due to weather impacts, thereby allowing a more accurate estimation of the specific savings opportunities for each LDC. The climate regions were based on International Climate Zones from ASHRAE Standard 90.1-2007. Ontario includes Climate Zones 5, 6 and 7, as illustrated in Figure 5-2. Since Hydro One customers are located across the province, a weighted average approach was applied in the development of Hydro One’s segmentation and load profiles. The mapping of LDCs to IESO zones informed the appropriate mapping of the savings opportunities to the IESO zones.

Figure 5-2: Ontario Climate Zones

5.1.3 Segment LDC Customers by End Use

End use profiles were developed for each sector and Table 5-2 provides a summary of the end uses for the residential, commercial and industrial sectors. End use profiles from the IESO's End Use Forecaster (EUF) model were used to develop the end use profiles for this study.

Table 5-2 End Uses per Sector

Residential Sector	Commercial Sector	Industrial Sector
Lighting	Lighting Interior General	Motors Pumps
Plug Load	Lighting Interior High Bay	Motors Fans Blowers
Space Heating	Lighting Exterior	Motors Other
Space Cooling	Cooling DX	Compressed Air
Ventilation and Circulation	Cooling Chillers	Process Heating
Domestic Hot Water	HVAC Ventilation	Process Cooling

Residential Sector	Commercial Sector	Industrial Sector
Refrigerators	Heating	Process Specific
Freezers	Domestic Hot Water	Electrochemical
Dishwashers	Cooking	HVAC
Clothes Dryers	Refrigeration	Lighting
Clothes Washers	Computer Equipment	Other
Cooking	Other Plug Loads	-
Dehumidifiers	Miscellaneous	-
Miscellaneous	-	-

5.2 IESO Zone Profiles and Sector End Use Profiles

Each IESO zone energy use profile was provided to IESO in an Excel workbook. The ten IESO zones are:

- Bruce
- East
- Essa
- Niagara
- Northeast
- Northwest
- Ottawa
- Southwest
- Toronto
- West

An example of an IESO zone profile is provided in Table 5-3, and illustrates the allocation of electricity use by end use and subsector. The IESO zone profiles were used to develop the baseline and reference forecast for the potential analysis, which is discussed in Section 6.

Table 5-3 Example of IESO Zone Profile for the Residential Sector in Climate Zone 5

	Space Heating	Space Cooling	Domestic Hot Water	Ventilation and Circulation	Lighting	Cooking	Refrigerators	Freezers	Clothes Washers	Clothes Dryers	Dishwashers	Plug Load	Miscellaneous	Dehumidifiers
Single Family	14.2%	11.5%	17.5%	1.6%	18.6%	4.5%	7.0%	1.5%	0.6%	4.6%	2.0%	13.4%	2.6%	0.3%
Row House	18.9%	8.8%	19.8%	1.2%	16.9%	4.1%	7.2%	1.5%	0.6%	4.2%	1.9%	12.2%	2.4%	0.3%
MURB Low Rise	24.8%	7.1%	21.9%	1.0%	14.2%	3.5%	7.7%	1.6%	0.5%	3.5%	1.6%	10.3%	2.0%	0.2%
MURB High Rise	27.1%	8.6%	21.5%	1.2%	12.7%	3.1%	8.0%	1.7%	0.4%	3.1%	1.4%	9.2%	1.8%	0.2%
Low Income	19.7%	10.0%	19.8%	1.4%	16.4%	4.0%	6.6%	1.4%	0.6%	4.0%	1.8%	11.8%	2.3%	0.3%
Other Residential Buildings	19.7%	10.0%	19.8%	1.4%	16.4%	4.0%	6.6%	1.4%	0.6%	4.0%	1.8%	11.8%	2.3%	0.3%

6 Base Year and Reference Case Forecast

The previous section discussed the 2014 base year energy use and 2015 – 2035 energy use load forecasts that were developed for each IESO zone, based on LDC load forecasts. The individual LDC energy use, for the base year and load forecast, was aggregated to derive the IESO zones and provincial energy 2014 base year and 2015 – 2035 reference case forecast. The results are presented and discussed in this section.

The base year and reference case forecast provide the reference point to determine the potential savings. The estimated technical, economic and achievable potential scenarios, and the comparison with the base year and reference case, are discussed in the subsequent sections (Sections 7 to Section 9).

6.1 Methodology

The 2014 base year electricity loads and 2015 – 2035 load forecasts were developed for each IESO zone as described in Section 5. The provincial electricity 2014 base year loads and 2015 – 2035 l ad forecasts were derived from aggregating the loads of the IESO zones.

6.2 Base Year: 2014

Figure 6-1 illustrates the portion of electricity use contributed by each of the three sectors in the 2014 base year. The largest proportion of electricity was consumed by the commercial sector (57,279 GWh/year or 43%), while the residential sector (39,461 GWh/year) and the industrial sector (36,282 GWh/year) accounts for 30% and 27% respectively.

The breakdown of electricity use in the base year by subsectors and end uses are summarized in Figure 6-2 to Figure 6-7. In the residential sector:

- The single family subsector accounts for close to 83% of the total electricity use.
- 45% of the electricity use in the residential sector is attributed the following three end uses: space heating, lighting and plug loads
- Slightly more than 52% of the total electricity load is used by small offices, multi-unit residential common areas, other (miscellaneous) commercial buildings and non-food retail subsectors.
- General interior lighting uses about 28% of the total electricity, while an additional 20% is used by HVAC ventilation and miscellaneous equipment.

In the industrial sector:

- Nine of the 15 subsectors each use between 5% and 15% of the total electricity use, with the largest amounts used by the miscellaneous industrial and auto parts manufacturing subsectors.
- 54% of the electricity is used by other motors, pump motors and compressed air.

Figure 6-1: Ontario Base Year (2014) Electricity Use by Sector

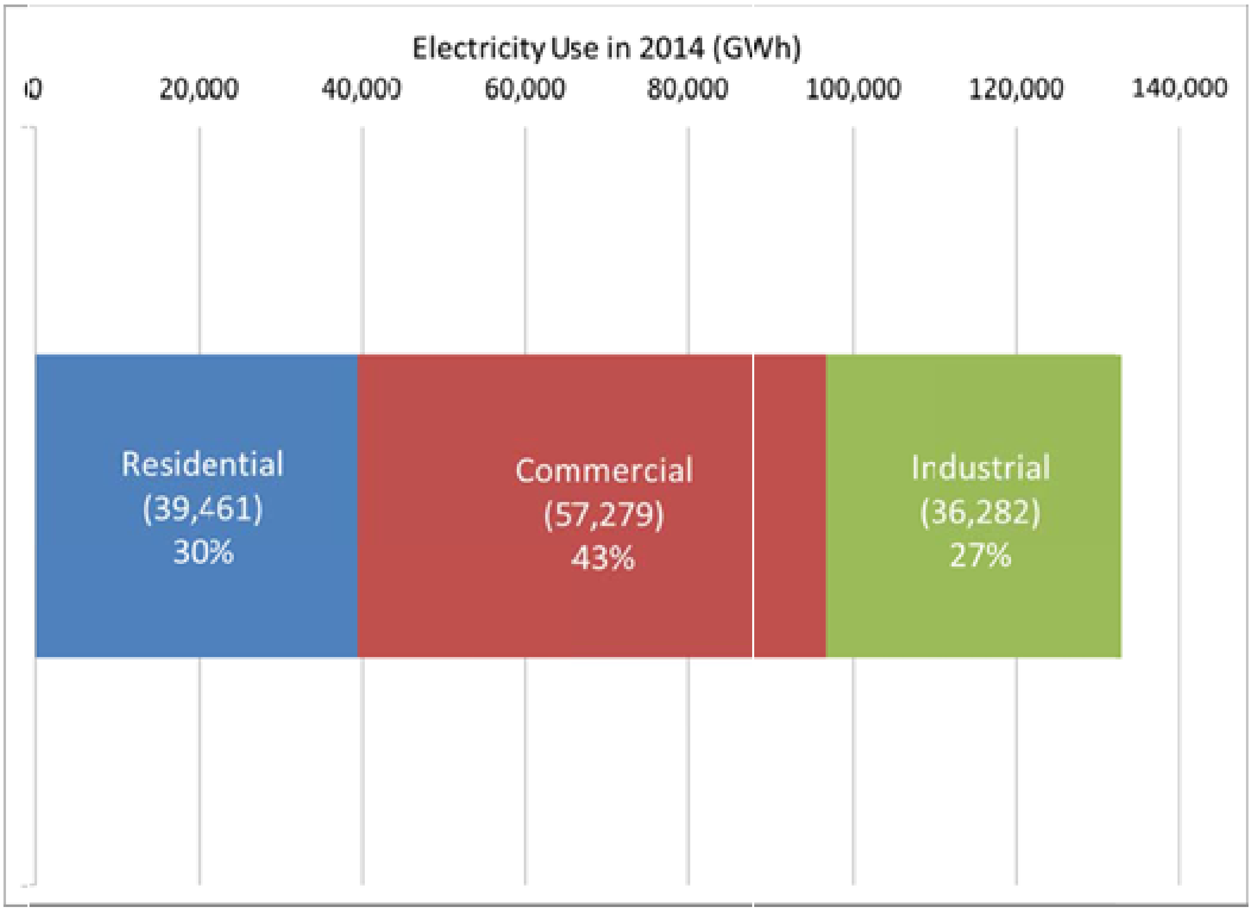


Figure 6-2: Residential Sector Base Year (2014) Electricity Use by Subsector (GWh/year)

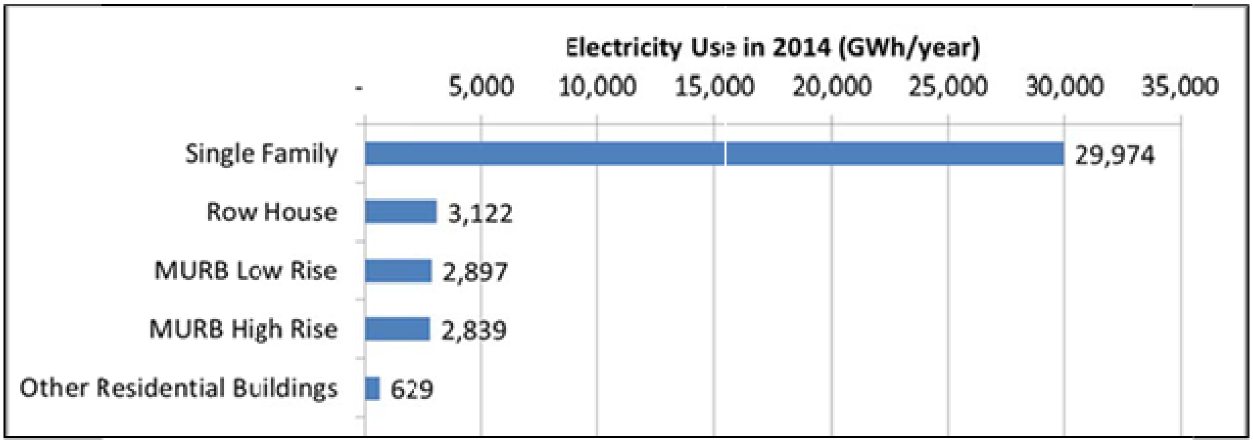


Figure 6-3: Residential Sector Base Year (2014) Electricity Use by End Use (GWh/year)

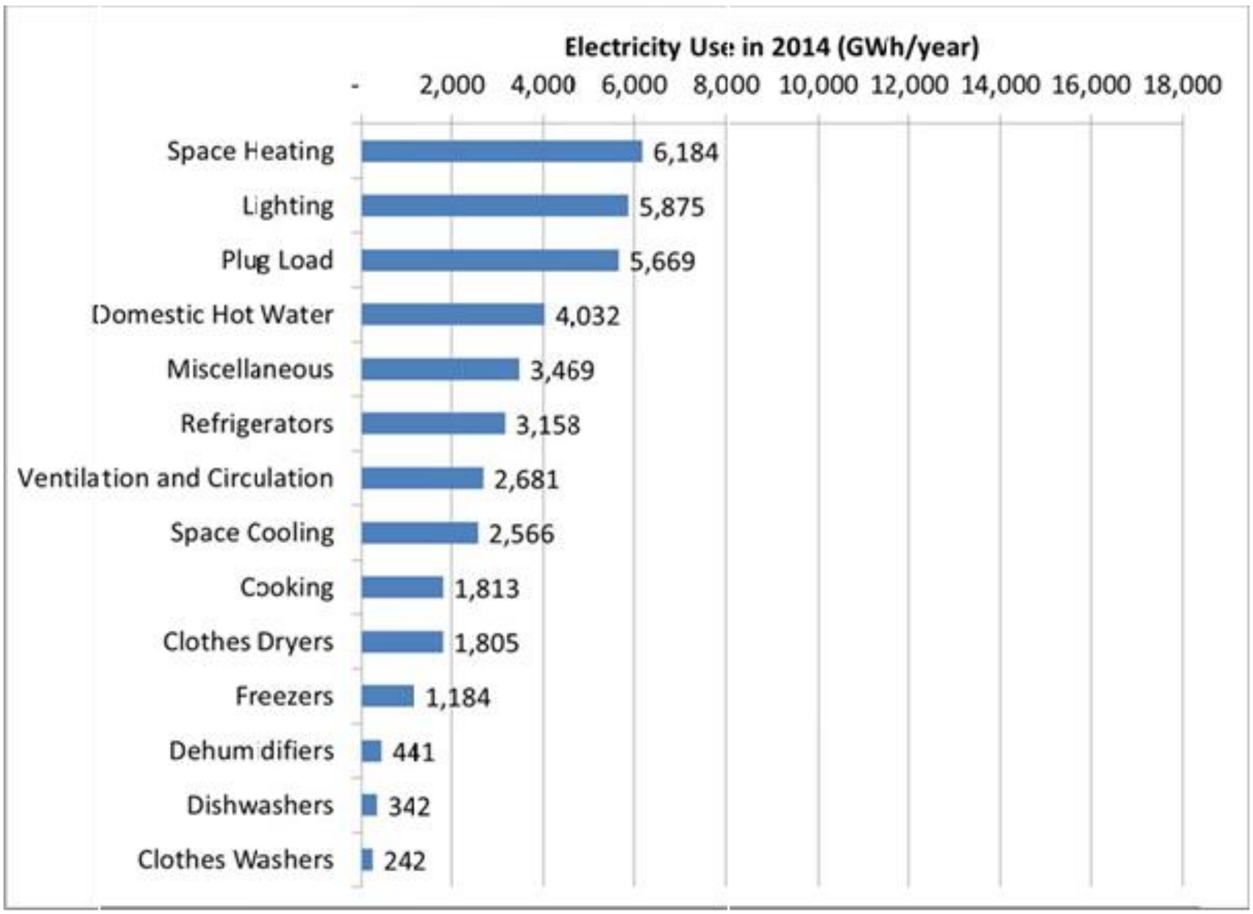


Figure 6-4: Commercial Sector Base Year (2014) Electricity Use by Subsector (GWh/year)

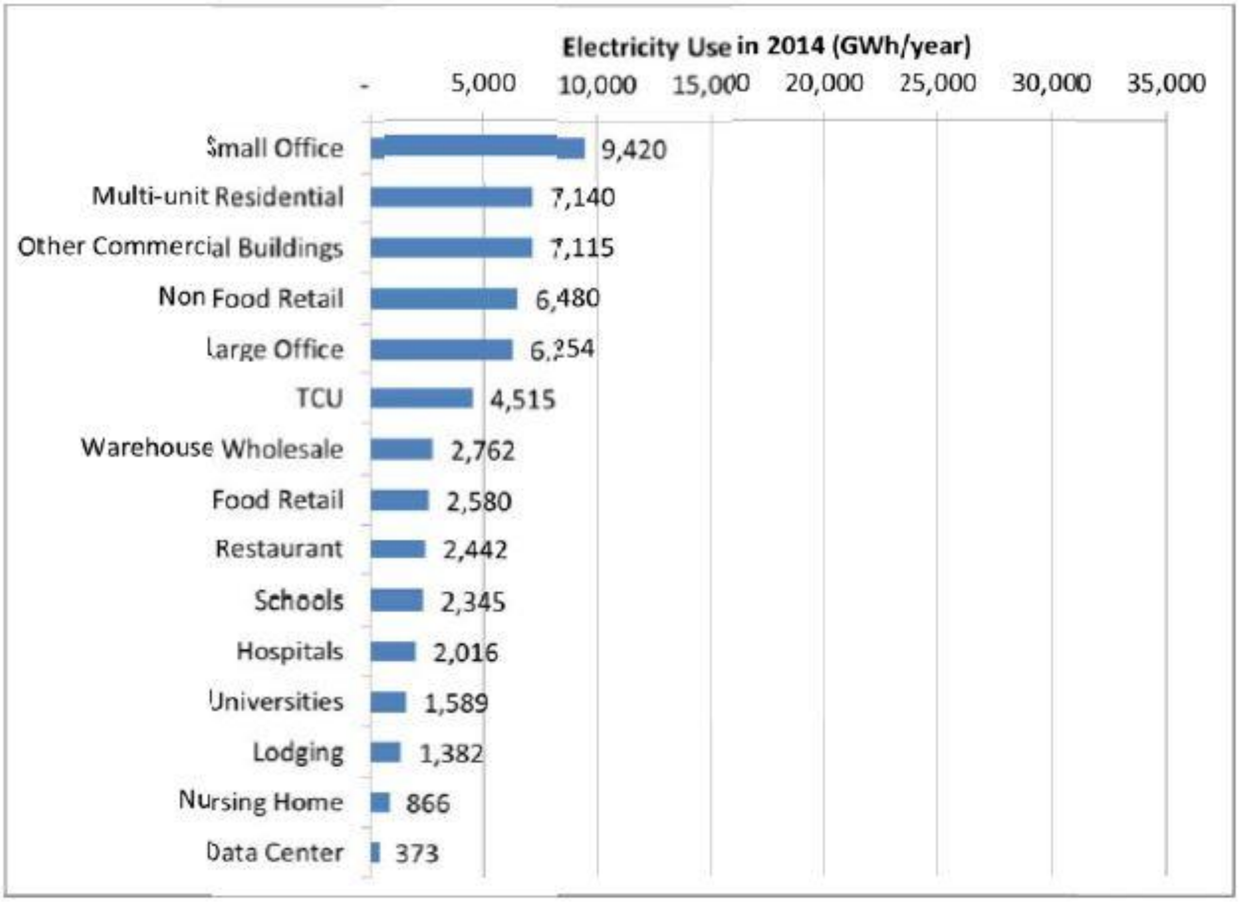


Figure 6-5: Commercial Sector Base Year (2014) Electricity Use by End Use (GWh/year)

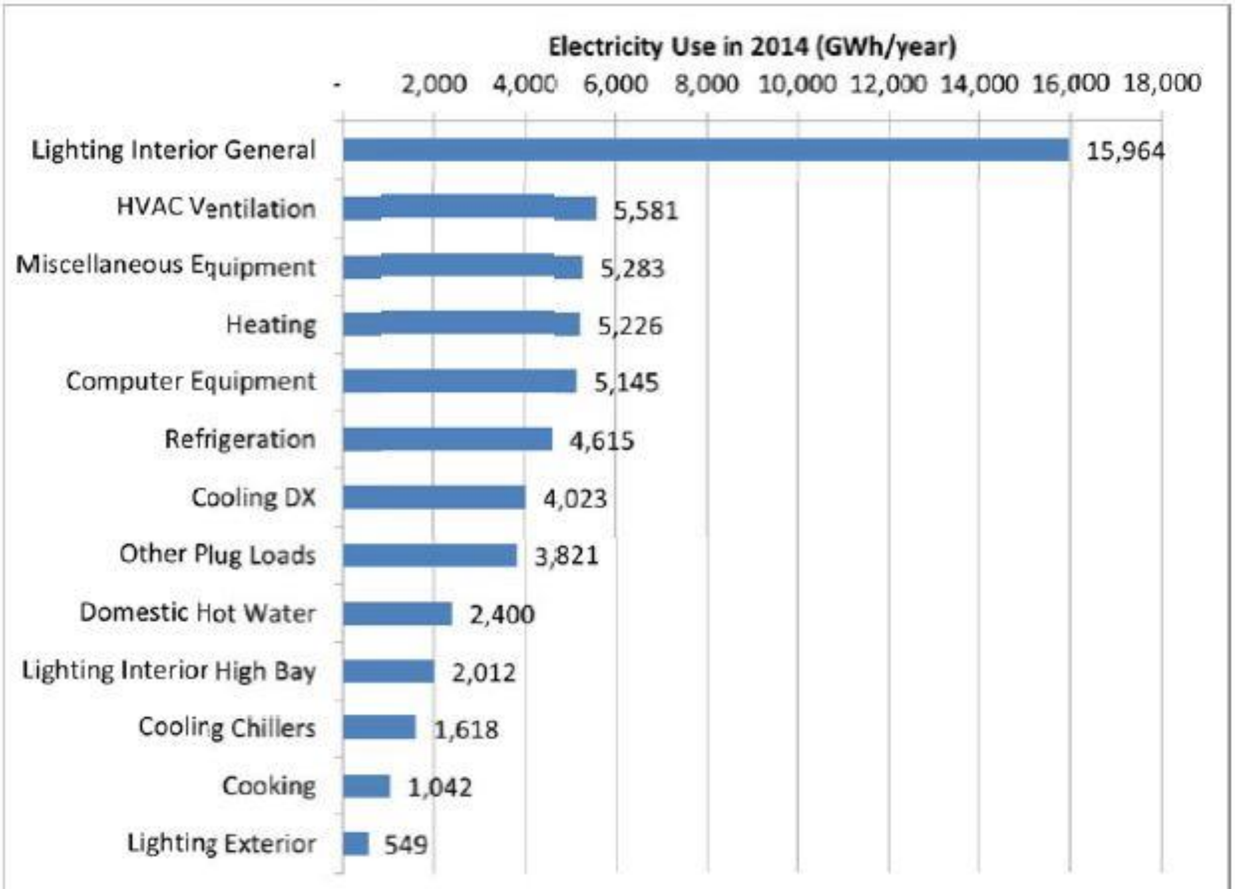


Figure 6-6: Industrial Sector Base Year (2014) Electricity Use by Subsector (GWh/year)

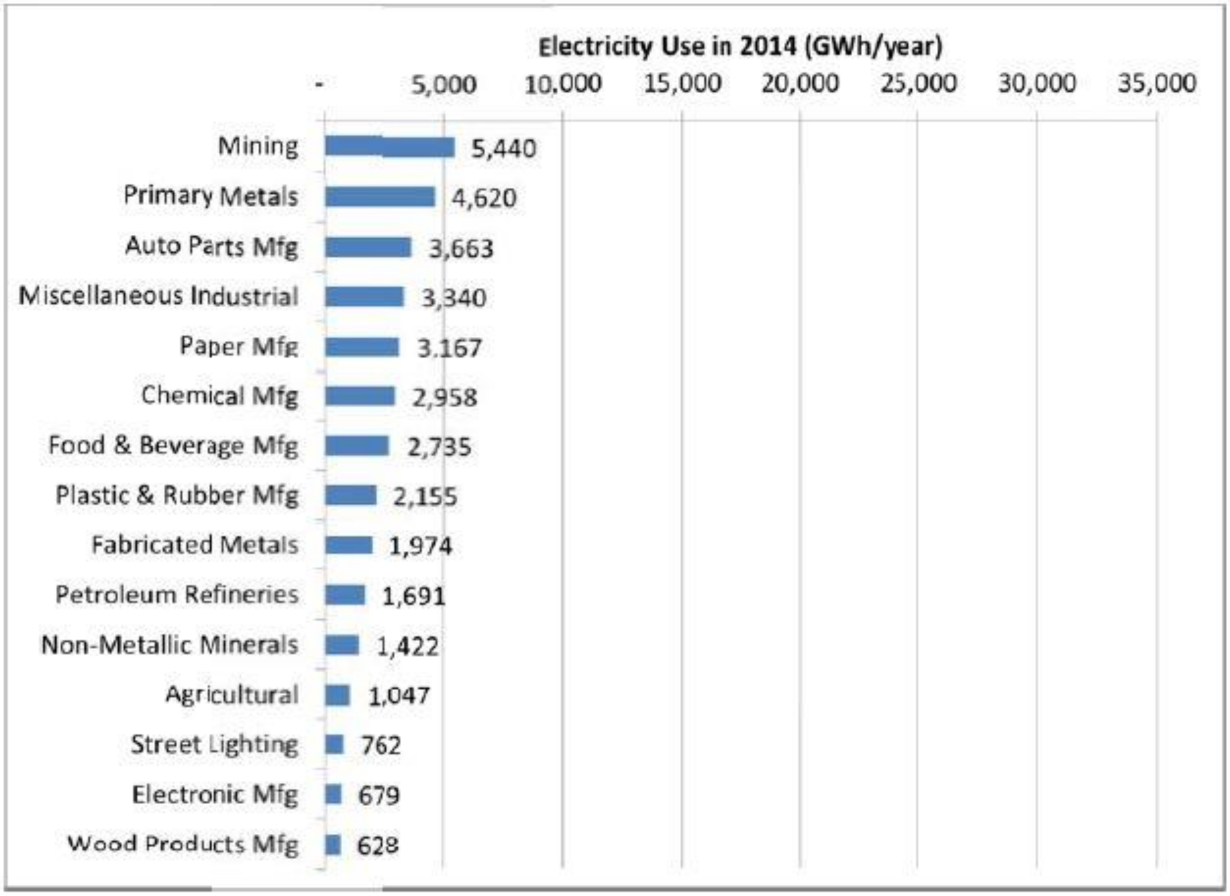
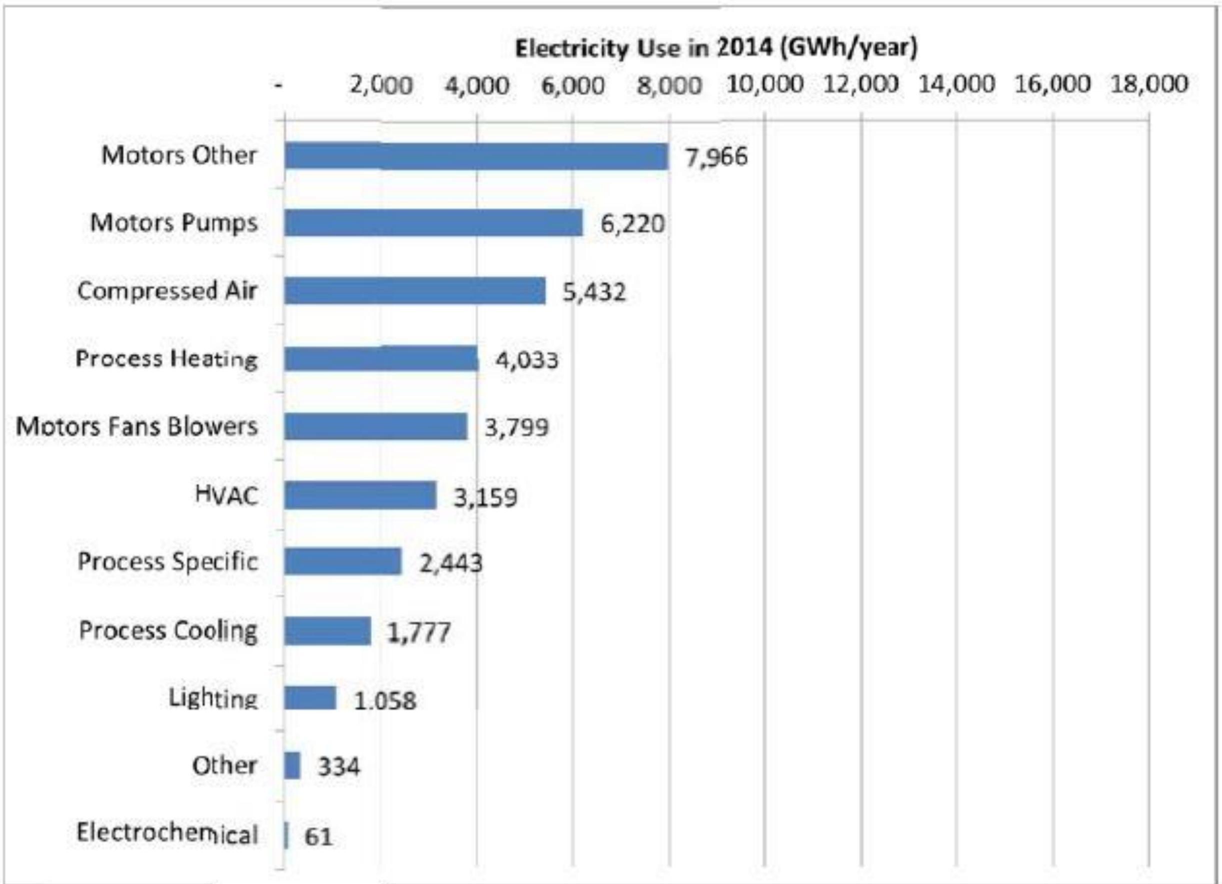


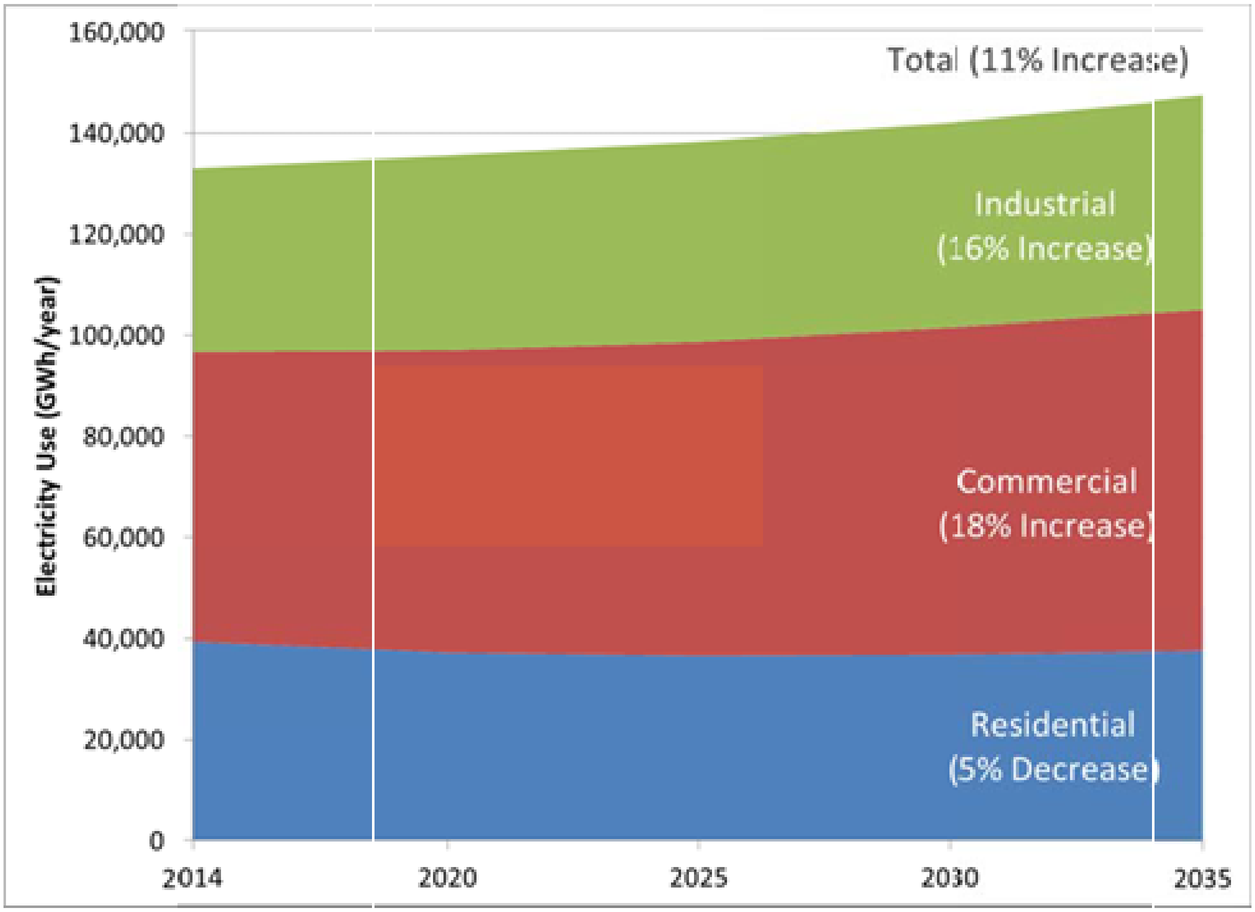
Figure 6-7: Industrial Sector Base Year (2014) Electricity Use by End Use (GWh/year)



6.3 Reference Case Forecast: 2015 – 2035

When compared to the base year of 2014, the load forecast for 2015 to 2035 estimates a total increase in electricity use of 11% from 133,022 GWh in 2014 to 147,147 GWh in 2035, as illustrated in Figure 6-8. The commercial sector is expected to provide the largest increase in electricity use, rising to 67,497 GWh by 2035 (an 18% increase). The residential sector electricity use is expected to show a slight decrease of 5%, dropping to 37,632 GWh in 2035, while the industrial sector electricity use is expected to increase by 16% to 42,017 GWh in 2035.

Figure 6-8: Ontario Forecast (2015 - 2035) Electricity Use by Sector



The 2015 – 2035 provincial load forecasts by subsector and end use are summarized in Figure 6-9 to Figure 6-14. The following can be observed from the forecast:

- In absolute terms, the largest decrease in electricity consumption in the residential sector is expected to occur in the single family subsector. At the end use level, space heating and lighting show the largest reduction in electricity use, while plug loads are expected to increase the most.
- Increased electricity usage is expected for all commercial subsectors, except for non-food retail and food retail, which is expected to decrease in electricity use, and hospitals and nursing homes, which is expected to remain relatively unchanged.

- In the industrial sector, a substantial increase in electricity use is expected in chemical manufacturing and mining, followed by relatively significant increases in the miscellaneous industrial, food and beverage manufacturing, and auto parts manufacturing subsectors. Decreases in electricity use are expected in the paper manufacturing and primary metals manufacturing subsectors. Increased electricity consumption is expected to occur in all end uses, with the highest amount of increase in process heating and process specific end uses.

Figure 6-9: Residential Sector Load Forecast (2015 to 2035) by Subsector

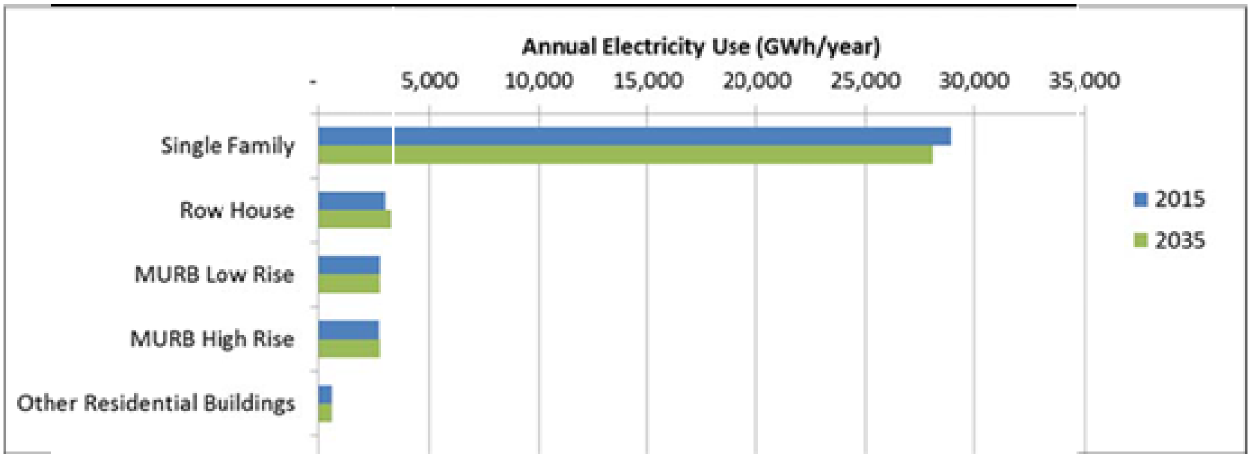


Figure 6-10: Residential Sector Load Forecast (2015 to 2035) by End Use

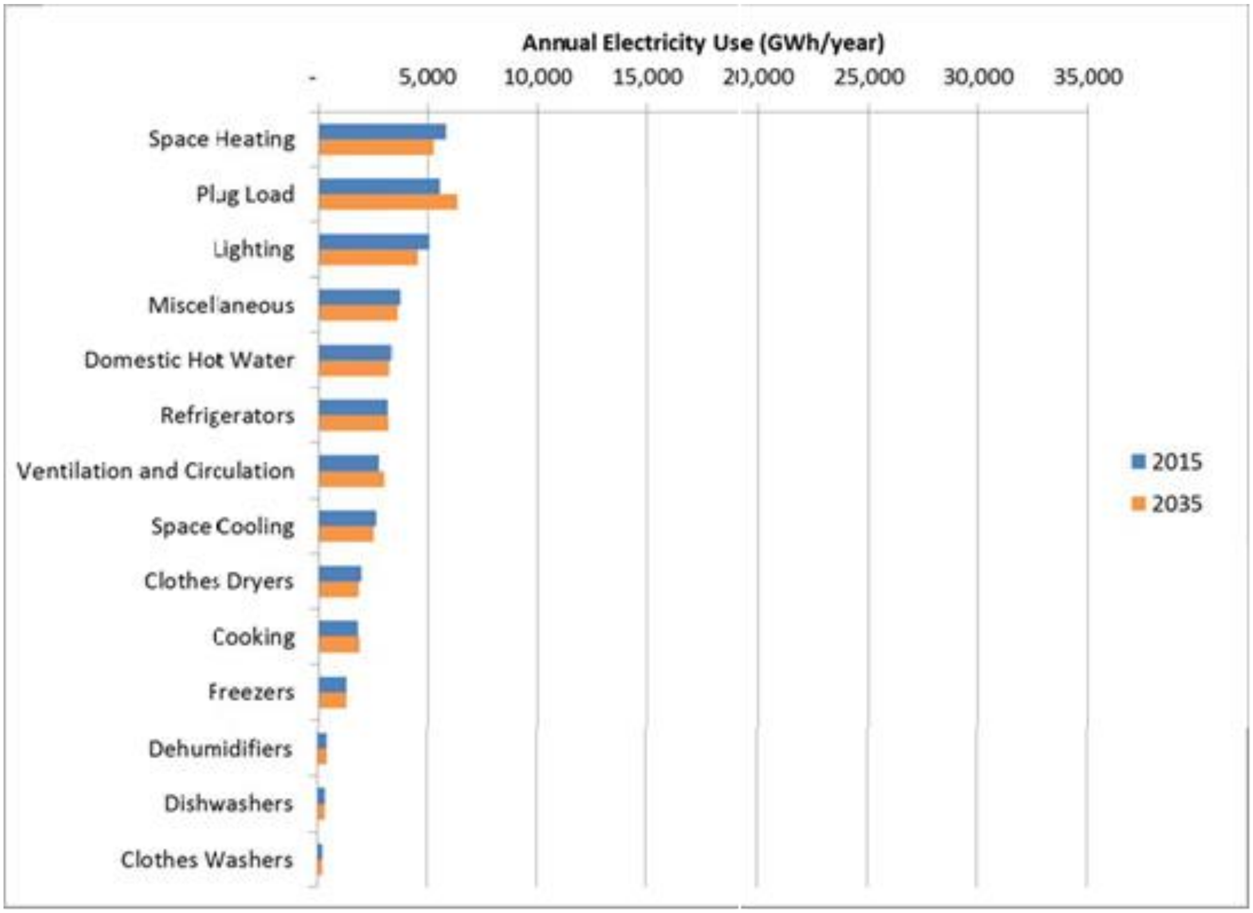


Figure 6-11: Commercial Sector Load Forecast (2015 to 2035) by Subsector

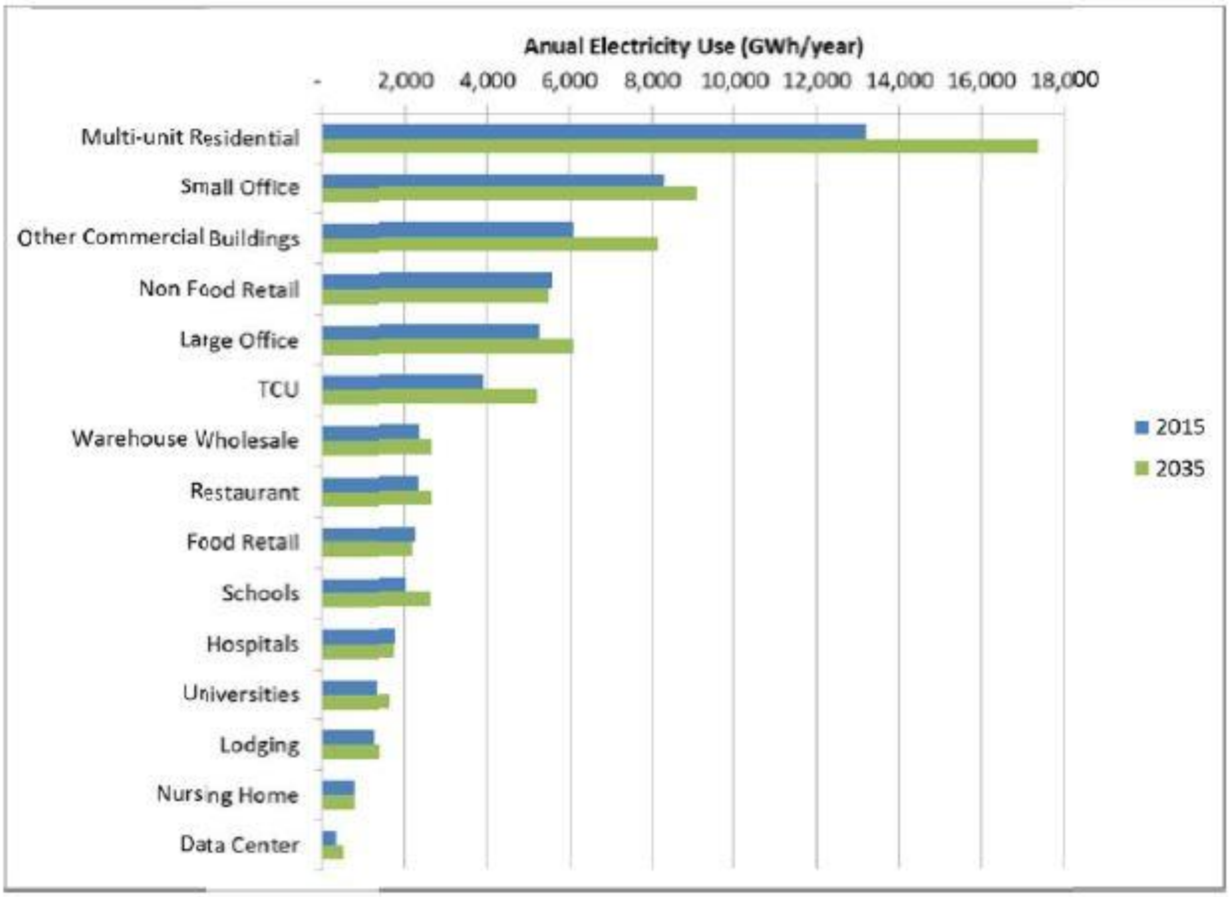


Figure 6-12: Commercial Sector Load Forecast (2015 to 2020) by End Use

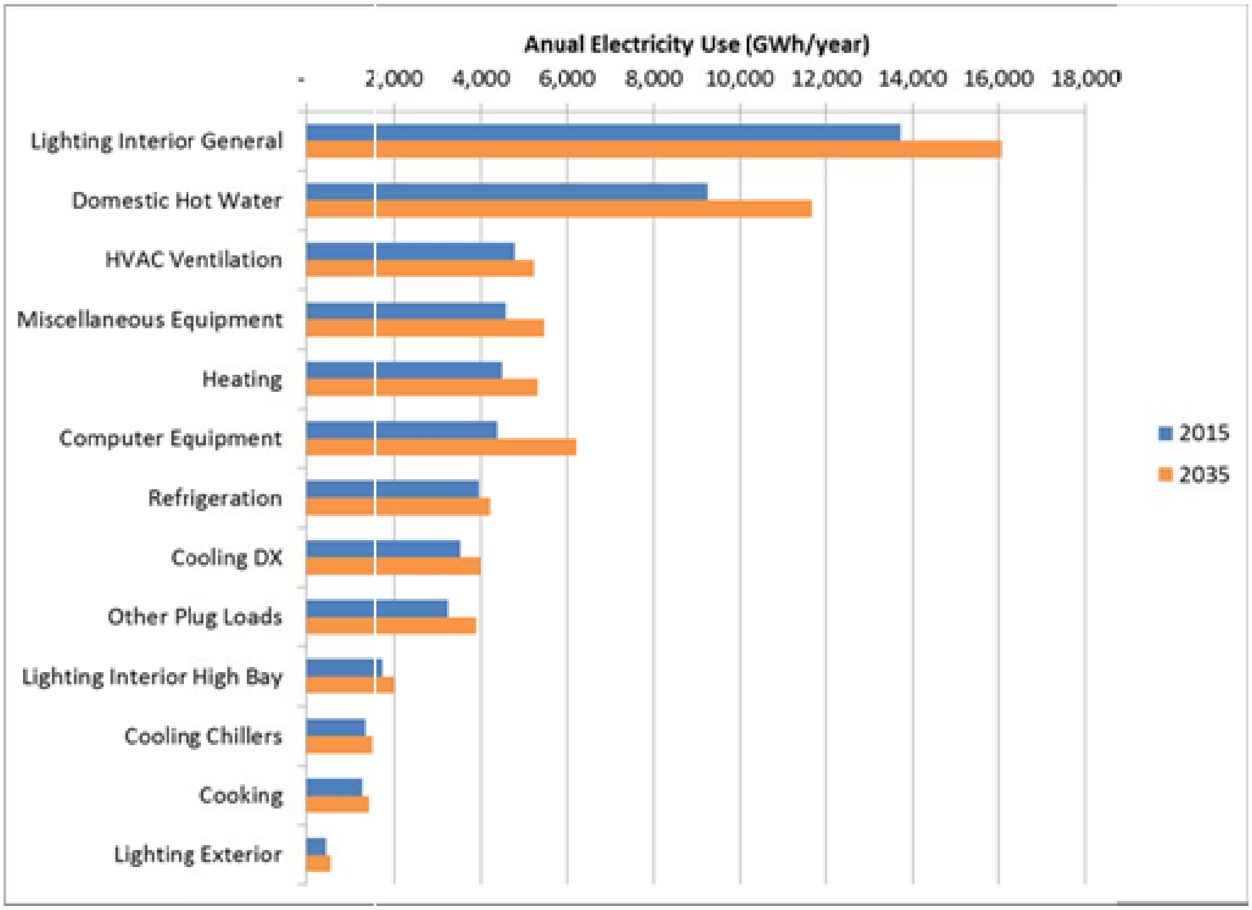


Figure 6-13: Industrial Sector Load Forecast (2015 to 2035) by Subsector

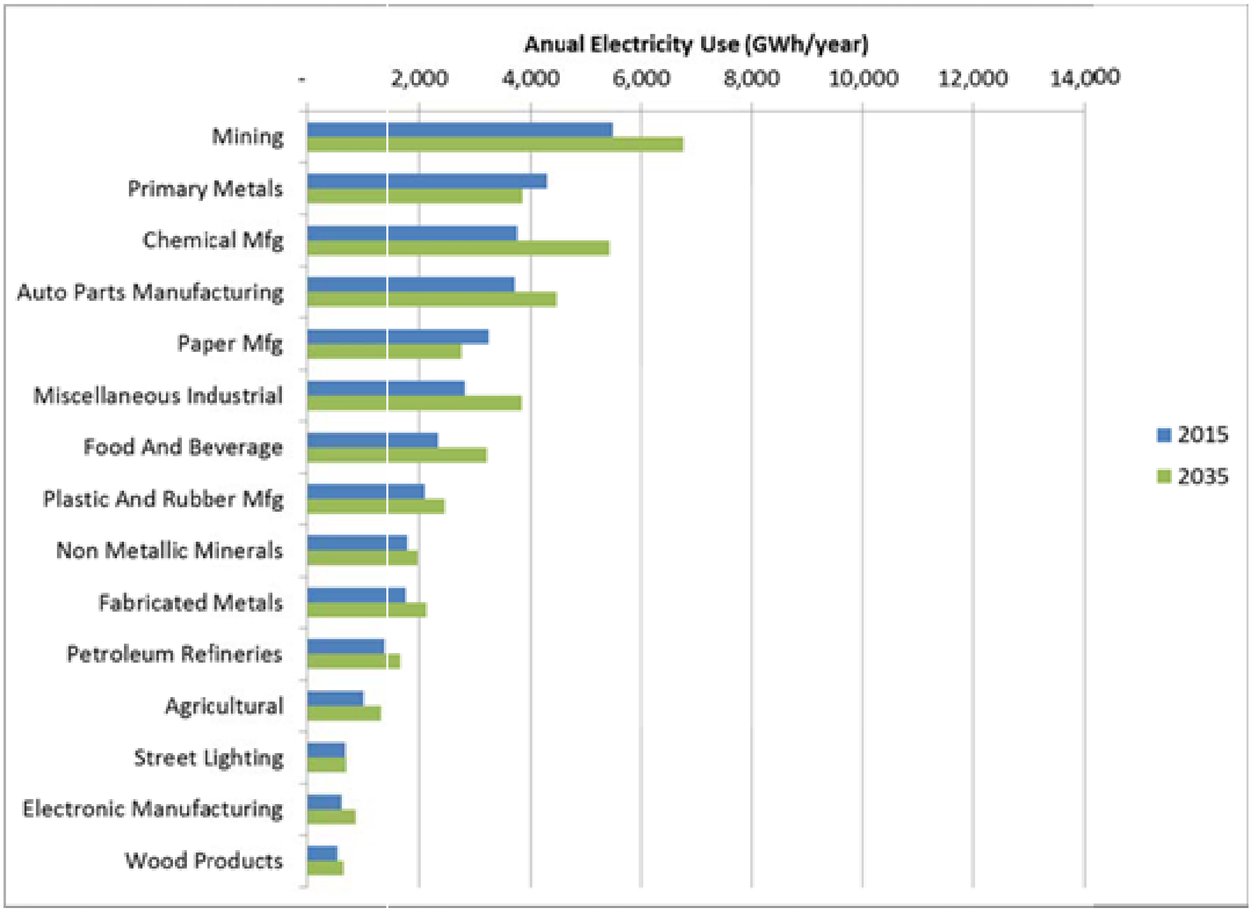
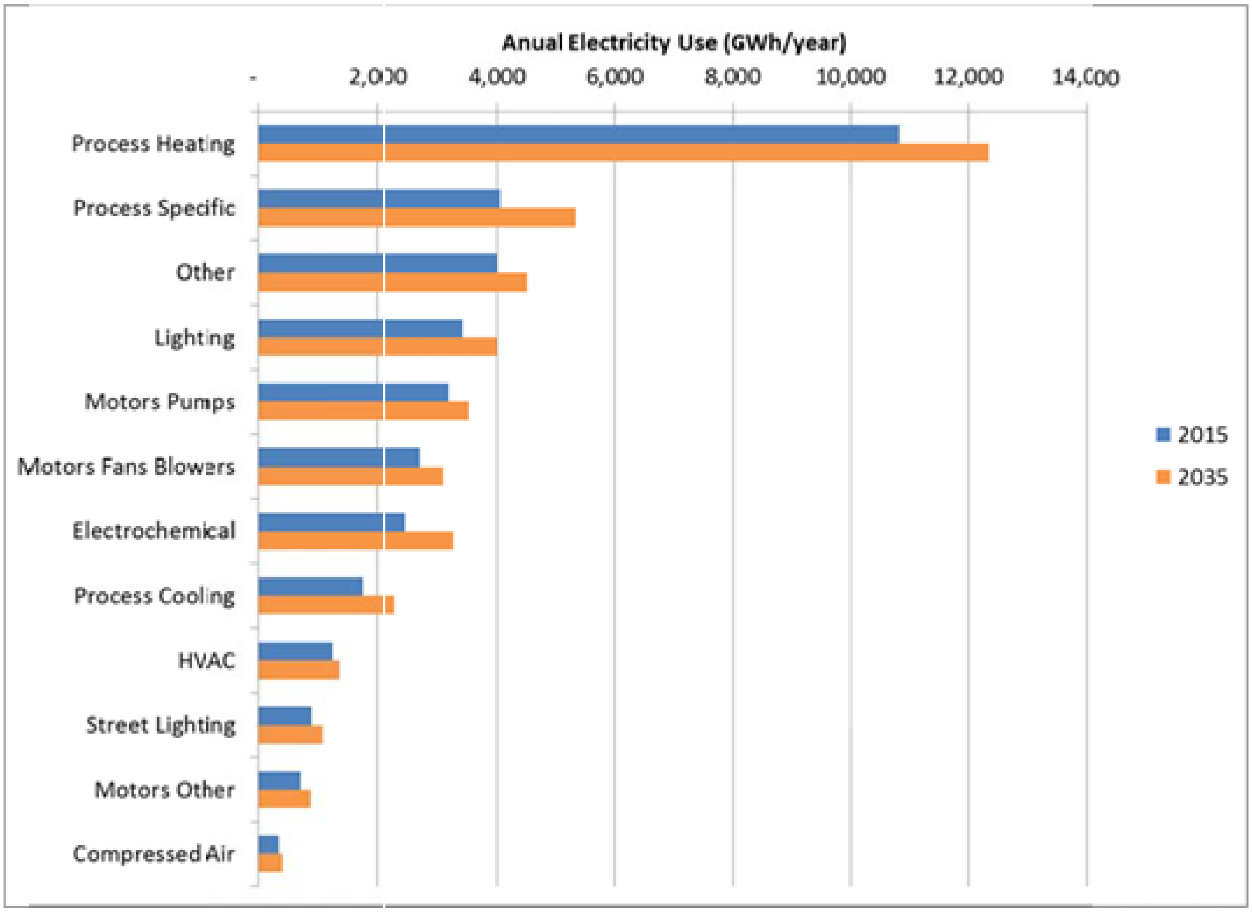


Figure 6-14: Industrial Sector Load Forecast (2015 to 2035) by End Use

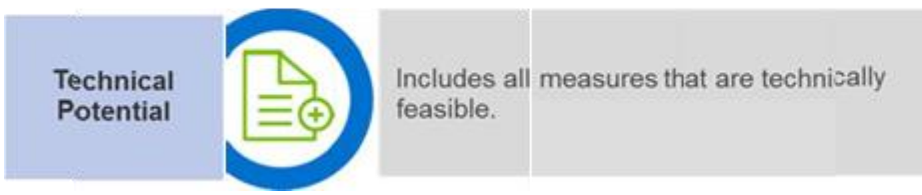


7 Technical Potential Scenarios

In the previous sections, energy efficiency measures were identified and characterized (Section 4), IESO zone profiles were developed (Section 5), and the 2014 base year and reference case forecast for 2015 to 2020 were developed (Section 6). The outputs from these tasks provided the input for the estimation of the technical potential scenario, which is discussed in this section.

The technical potential scenario estimates the savings potential when all technically feasible energy efficiency measures are implemented at their full market potential, while taking equipment turnover rates into account This savings potential can be considered as a maximum potential.

The subsequent sections (Sections 8 and 9) will discuss the estimation of economic and achievable potential scenarios.



7.1 Methodology

The main steps in estimating the technical savings potential include:

- Mapping energy efficiency measures to end uses.
- Run measures through Nexant Technical, Economic and Achievable Potential (TEA-POT) model to assess energy efficiency potential for each measure.
- Aggregate measure savings potential to derive end use potential savings by IESO zone and aggregate IESO zone potential savings to derive provincial potential savings.

These steps are described in more detail in the remainder of this section.

7.1.1 Mapping EE Measures to End Uses

End uses were defined for each of the sectors, and are summarized in Table 7-1.

Table 7-1 Sectors and End Uses

Sector	Residential	Commercial	Industrial
End Uses	Space Heating	Lighting Interior General	Process Heating
	Space Cooling	Lighting Interior High Bay	Process Cooling
	Ventilation and Circulation	Lighting Exterior	Compressed Air
	Domestic Hot Water	Computer Equipment	Motors Pumps
	Lighting	Other Plug Loads	Motors Fans Blowers
	Cooking	Cooking	Motors Other
	Refrigerators	Refrigeration	Process Specific
	Freezers	Heating (Baseboards, Central)	Lighting
	Clothes Washers	Cooling Chillers	HVAC
	Clothes Dryers	Cooling DX	Electrochemical
	Dishwashers	HVAC Ventilation	Other
	Dehumidifiers	Domestic Hot Water	
	Plug Load	Miscellaneous Equipment	
	Miscellaneous		

As described in Section 4, in de eloping the measure profiles, each measure is mapped to an end use. The end use allocation is included in each measure workbook, provided as separate Excel workbooks.

7.1.2 Model Energy Efficiency Potential for Each Measure

Each technically feasible measure was run through Nexant's Technical, Economic and Achievable Potential (TEA-POT) model to assess energy efficiency potential for each measure.

This assessment is necessary in order to:

- *Develop measure interactions* and measure competition groups.
- Integrate *measure ranking logic*, which arranges and applies measures in order of cost effectiveness.
- *Avoid double-counting potential savings* (repeat participation) by limiting total adoption to 100% within measure competition group by end use or archetype program.
- Iteratively *reduce the baseline forecast* after the application of each subsequent measure.

The core equation used in the residential sector energy efficiency potential analysis is shown in Equation 1 below, while the core equation utilized in the non-residential sector potential analysis for each individual measure is shown in Equation 2 below.

Equation 1: Core Equation for Residential Sector – Measure Savings Potential

Potential of Efficient Measures = Total Number of Households × Base Case Equipment Energy Use Intensity (kWh/unit) × Saturation Share × Remaining Factor × Applicability Factor × Savings Factor

Parameter	Definition
Total number of households	Number of households eligible and adopting a given measure.
Base equipment energy use intensity	Amount of kWh consumed per year for baseline equipment.
Saturation/Fuel share	Percentage of households with the measure's electric end use present (e.g. share of homes with electric water heating).
Remaining Factor	Fraction of equipment that is not already energy efficient, which takes into account historical savings and persistence of the savings.
Applicability Factor	Fraction of applicable units that are technically feasible for conversion to efficient technology (e.g. it is not technically feasible to install heat pump water heaters in all homes). Care was taken so that the applicability factor does not overlap with the remaining factor.
Savings Factor	Percentage reduction in energy consumption with efficient equipment.

Equation 2: Core Equation for Non-residential Sector – Measure Savings Potential

Potential of Efficient Measures = Total Stock Sq. Footage by Building Type by LDC × Base Case Equipment Energy Use Intensity (kWh/unit) × Equipment Saturation Share × Remaining Factor × Applicability Factor × Savings Factor

Parameter	Definition
Total stock sq. footage by building type by LDC	The forecasted aggregated square footage for a given building type that adopts a given measure.
Base equipment energy use intensity	The electricity used per square foot per year by each base-case equipment and/or end use in each subsector.
Equipment Saturation/Fuel share	Percentage of square footage served by a given measure's electric end use (e.g. percentage of floor space served by electric water heating).
Remaining Factor	Fraction of equipment that is not already energy efficient, which takes into account historical savings and persistence of the savings.
Applicability Factor	Fraction of applicable units that are technically feasible for conversion to efficient technology.
Savings Factor	Percentage reduction in energy consumption with efficient equipment.

As part of the short term potential analysis, LDC profiles were developed for each of the 75 LDCs. The methodo ogy and output associated with this task is described in the report for the short term analysis. Some of the input data used in the equations, described above, were derived from the development of the LDC profiles.

7.1.3 Provincial Potential Savings

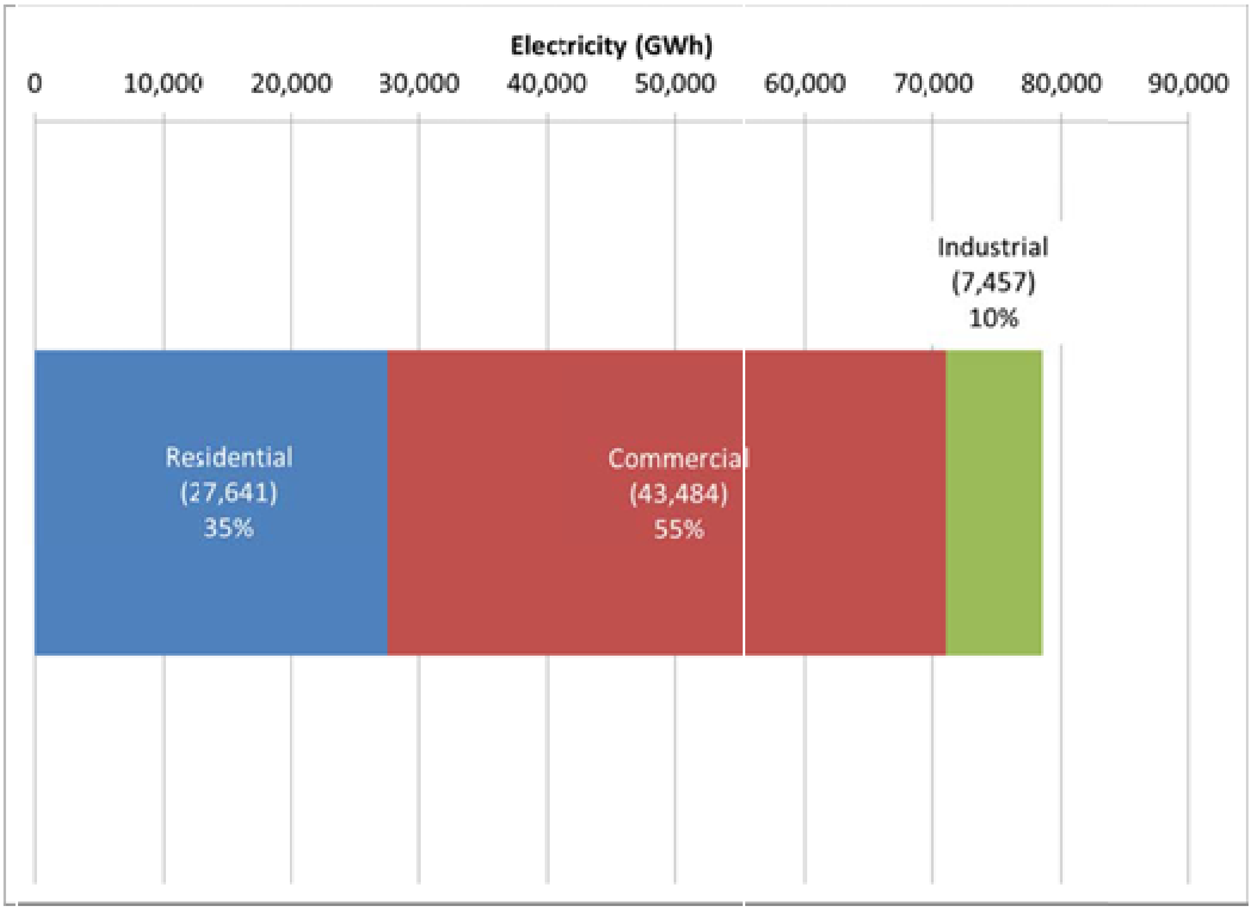
The output of the previous step is a detailed matrix table that shows each measure permutation (by sector, by subsector, by end use, by vintage, and by climate region) with the associated savings potential and costs. Using the mapping of measures to end uses and the savings per measure from the previous step, the measure savings are aggregated to produce the potential savings per end use, by sector per IESO zone. The resulting potential savings per IESO zone was aggregated to produce an estimate of technical potential savings at the provincial level.

7.2 Results and Discussion

7.2.1 Portfolio

The technical potential in 2035 is estimated to be an annual saving of 78,581 GWh (or 53% of the total electricity use in 2035). The largest proportion of this savings is from the commercial sector (55%), while the residential industrial sector account for account for 35% and 10% of this savings, respectively (illustrated in Figure 7-1).

Figure 7-1: Technical Potential Persistent Savings by Sector in 2035



7.2.2 Residential Sector

In the residential, sector the largest technical potential is estimated for the single family subsector, which accounts for 73% of the residential persistent savings in 2035 (as illustrated in Figure 7-2). 86% of the estimated persistent savings in 2035 are from four end uses: lighting (27%), space heating (23%), domestic hot water (14%) and space cooling (12%) (see Figure 7-3).

Figure 7-2: Technical Potential Persistent Savings by Residential Subsector in 2035

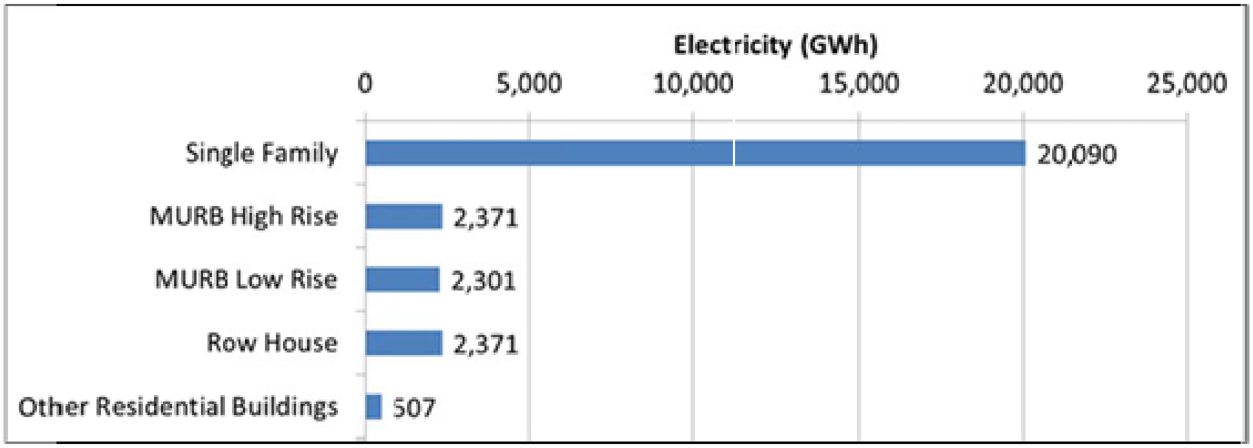
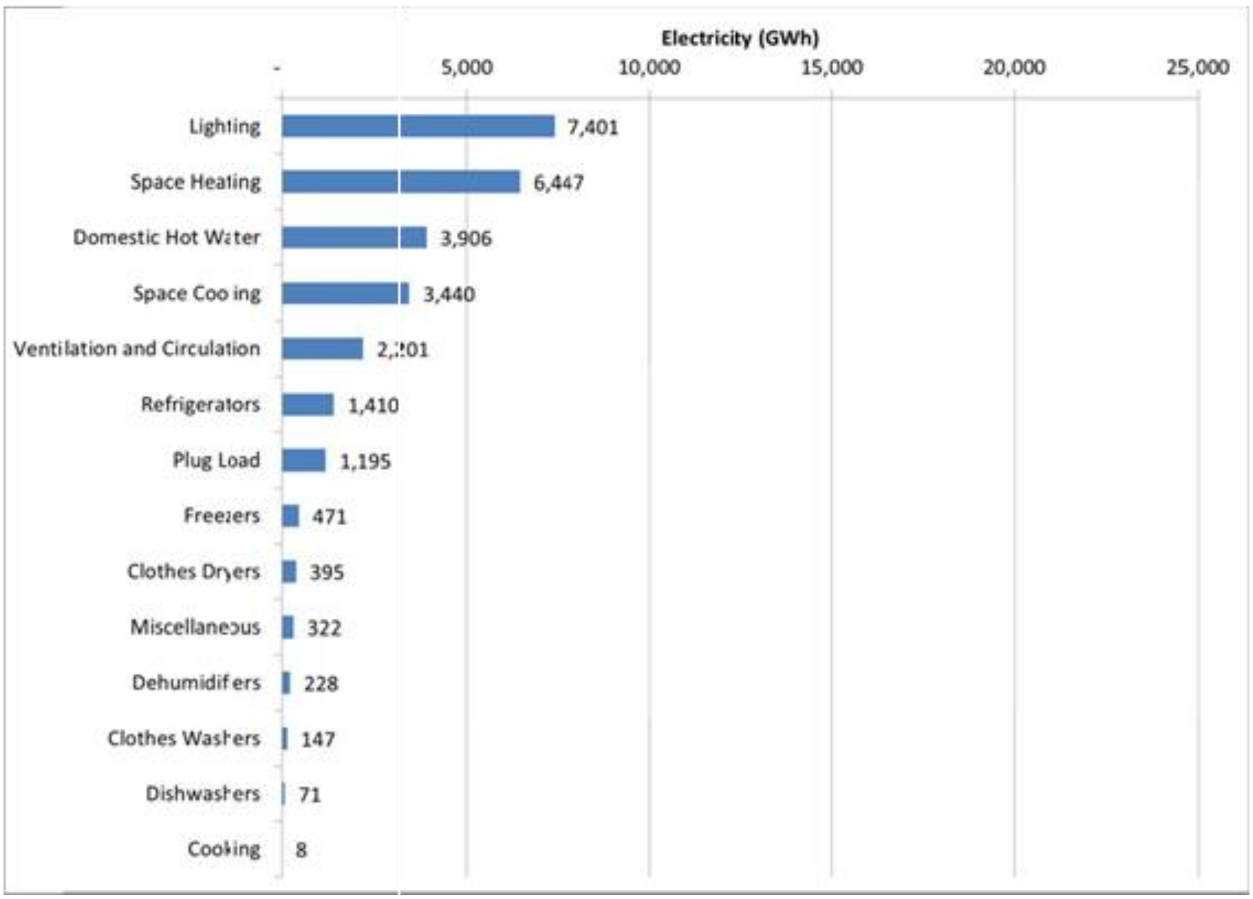


Figure 7-3: Technical Potential Persistent Savings by Residential End Use in 2035



7.2.3 Commercial Sector

In the commercial sector, six subsectors account for close to 75% of the persistent savings in 2035: multi-unit residential com on areas (16%), other commercial buildings (16%), small office (16%), large office (9%), TCU (9%) and non-food retail (7%) (see Figure 7-4). The lighting interior end use is estimated to result in 33% of the persistent savings in 2035 in the commercial sector. Other notable end use savings result from HVAC ventilation (14%) and cooling DX (12%), as illustrated in Figure 7-5.

Figure 7-4: Technical Potential Persistent Savings by Commercial Subsector in 2035

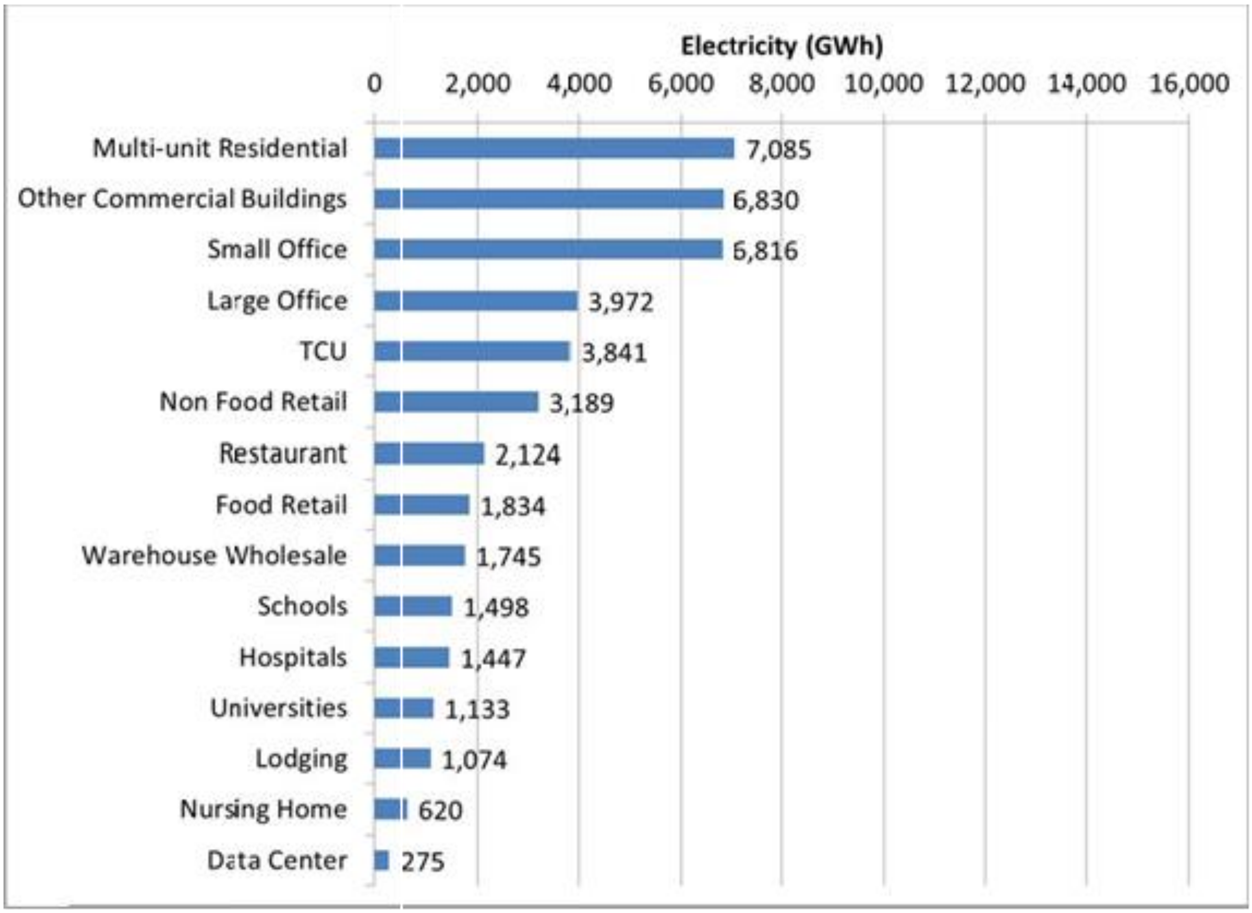
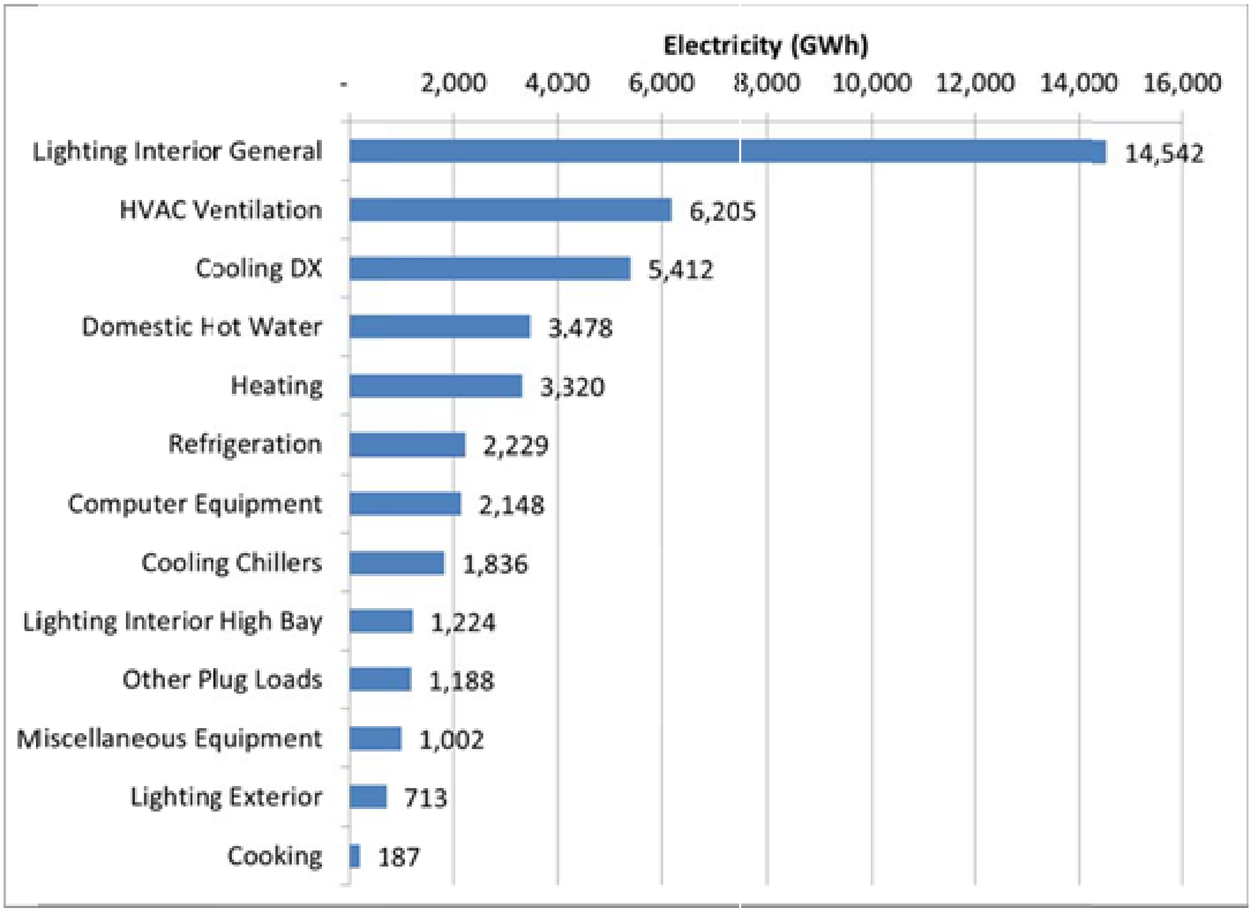


Figure 7-5: Technical Potential Persistent Savings by Commercial End Use in 2035



7.2.4 Industrial Sector

In the in ustrial sector, three subsectors each account for more than 10% of the persistent savings in 2035: mining (17%), chemical manufacturing (13%) and auto parts manufacturing (13%) (see Figure 7-6). Five end uses are estimated to account for close to 90% of the persistent savings in 2035 in the industrial sector: HVAC (31%), lighting (19%), compressed air (18%), motor pumps (11%) and motors on fans and blowers (11%), as illustrated in Figure 7-7.

Figure 7-6: Technical Potential Persistent Savings by Industrial Subsector in 2035

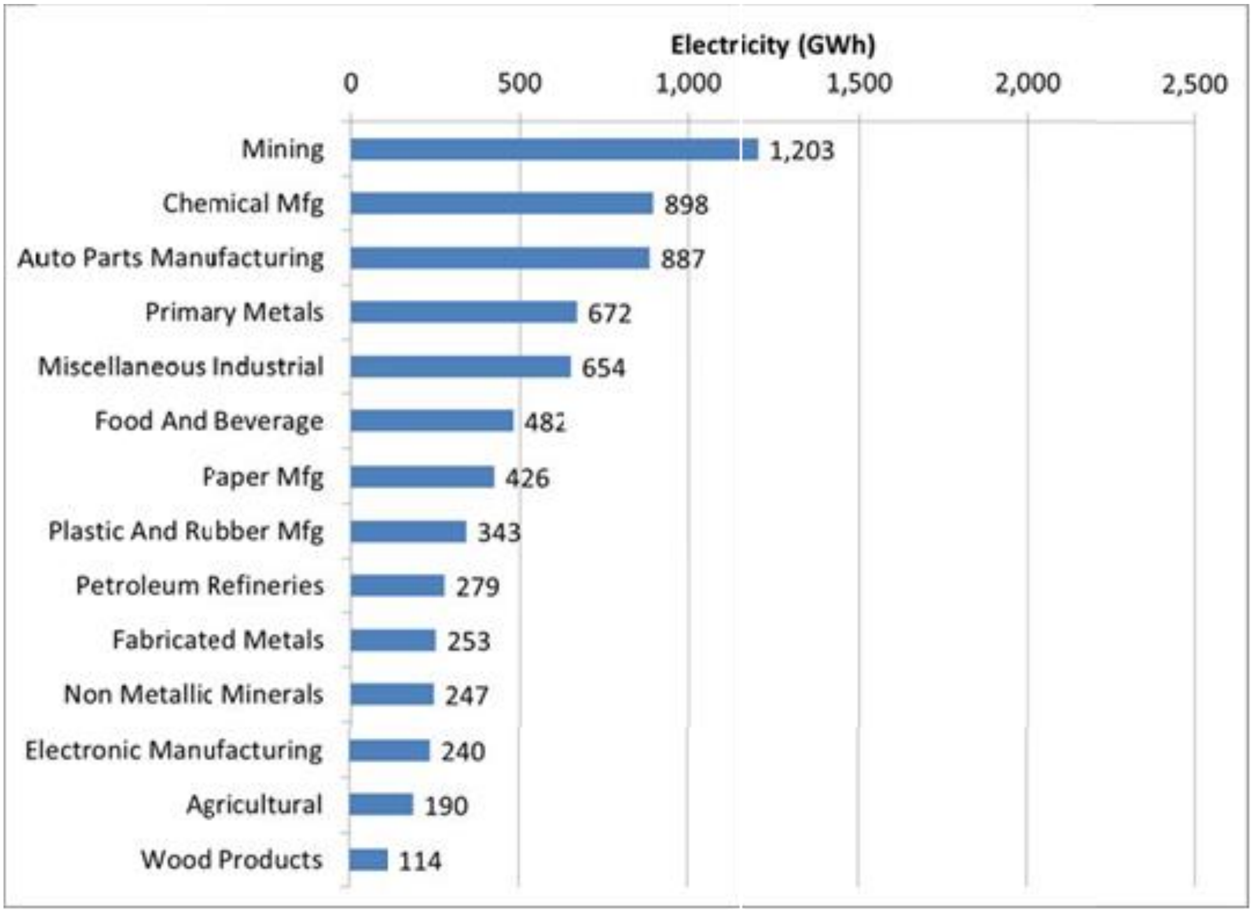
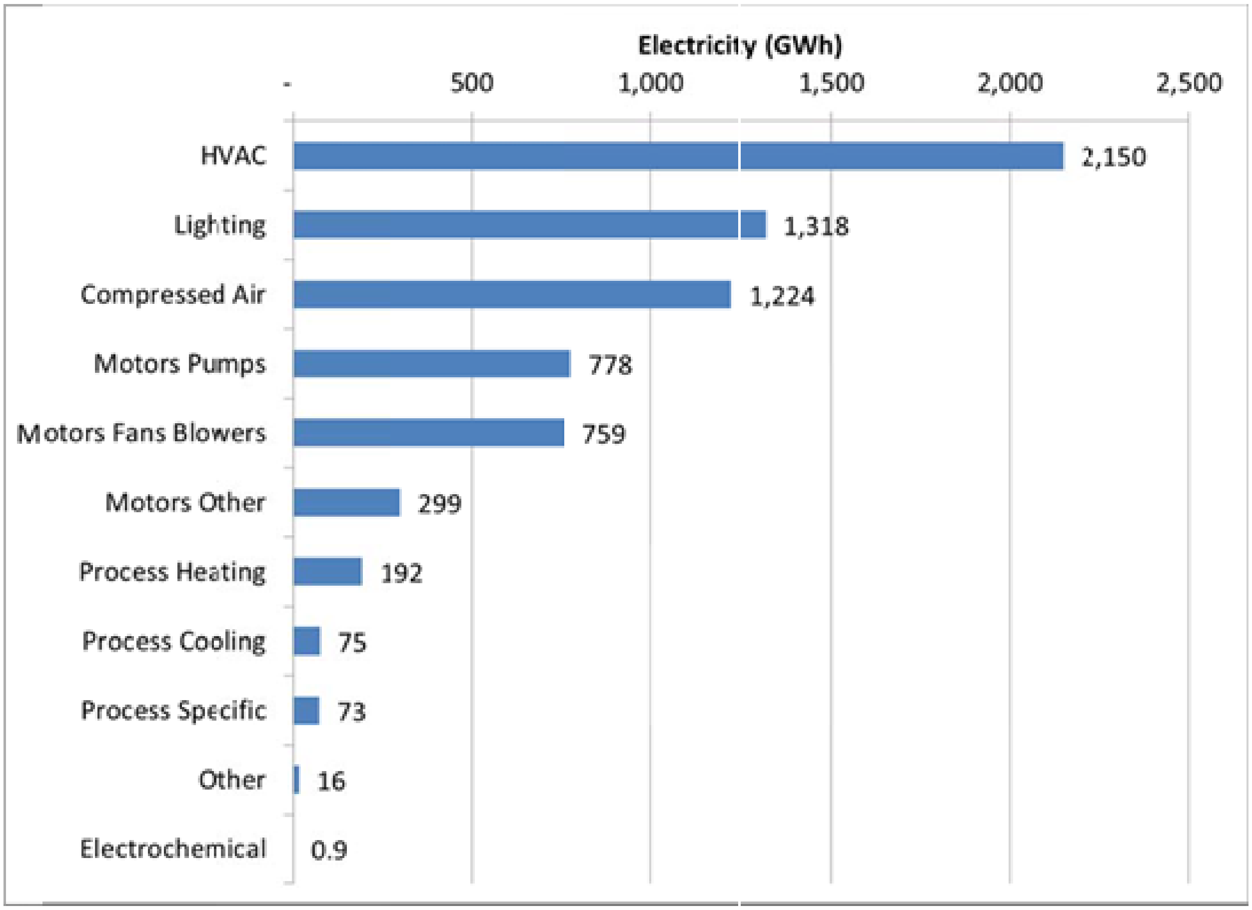


Figure 7-7: Technical Potential Persistent Savings by Industrial End Use in 2035



8 Economic Potential Scenarios

In the previous sections, energy efficiency measures were identified and characterized (Section 4), IESO zone profiles were developed (Section 5), and the 2014 base year and reference case forecast for 2015 to 2020 were developed (Section 6). The estimation of the potential savings for the technical potential scenario is described in the previous section (Section 7), and provides a key step towards the estimation of potential savings for the economic potential scenario. Whereas the technical potential scenario provides a maximum potential if all technically feasible energy efficiency measures are implemented, the economic potential scenario estimates the maximum potential if only the economically feasible EE measures are implemented.

The remainder of this section addresses the economic potential scenario, which provides a key step towards developing the achievable potential scenarios. The achievable potential scenarios are discussed in the subsequent section (Section 9).

8.1 Methodology

Economic potential is estimated through the modelling of the available savings potential of individual measures, taking into account measure-level interactive effects and competition, as well as measure-level cost effectiveness, which is described in the methodology for the technical potential scenario (see Section7.1). Using the technical potential as the starting point to develop the economic potential, the cost effectiveness of all the measures included in the technical potential scenario was screened. Measures with a measure vintage bundle average TRC > 0.75 was considered to be cost-effective and included in the economic potential scenario.

The TRC of a measure may differ by climate region, but the TRC of a measure will be the same for all IESO zones within the same climate region. The study uses three climate regions, as discussed in Section 5.

The savings potential of the EE measures were calculated for the technical potential scenario as described in Section 7.1. The sum of the savings for the economically feasible EE measures within an end use provides the savings potential for each of the end uses in the economic potential scenario. The savings were modelled within each year of the study horizon for each IESO zone.

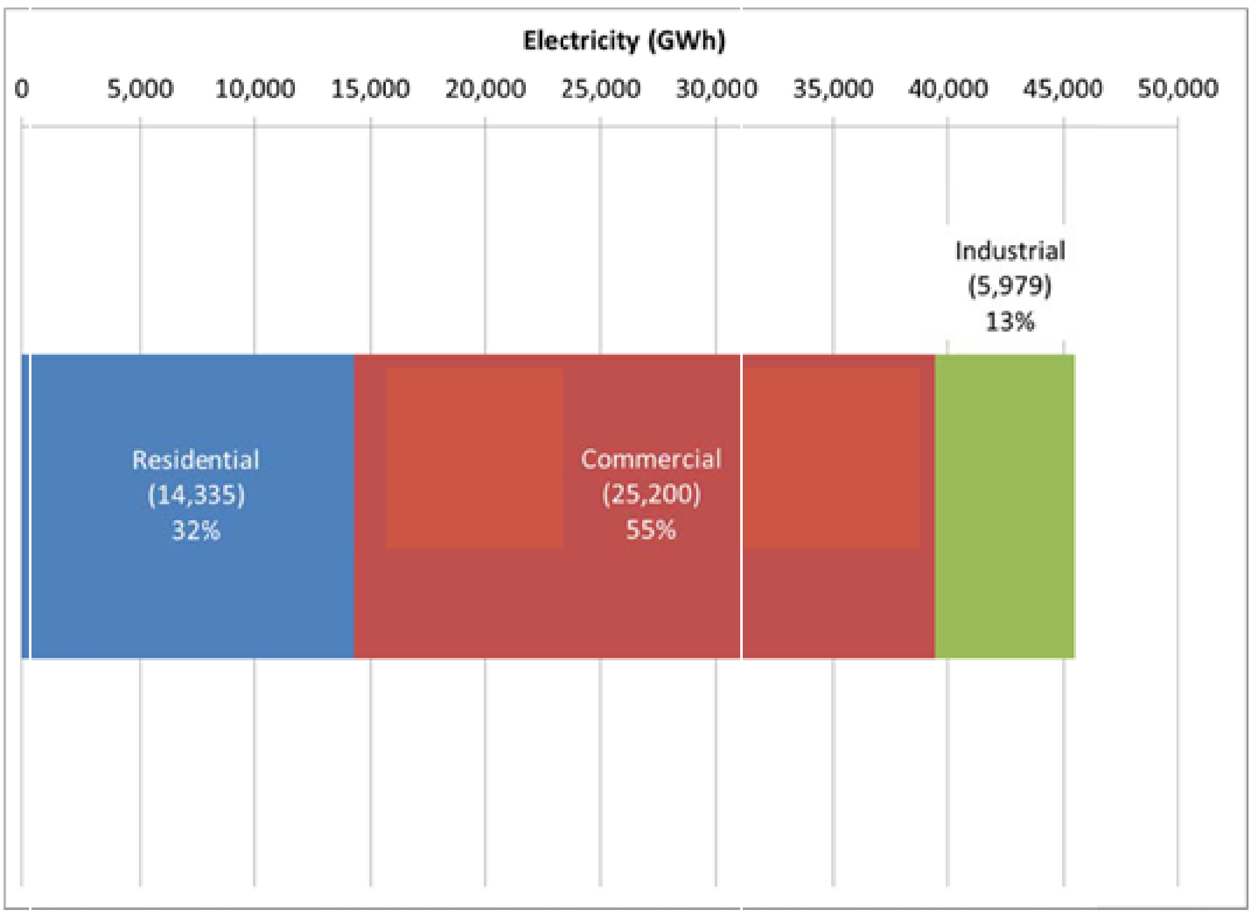
Savings are expressed as persistent savings over time, which takes into consideration measure life time. Therefore, savings will be persistent only for the duration of the measure life, after which the baseline technology that is applicable at the specific time will be used as the replacement of the measure.

8.2 Results and Discussion

8.2.1 Portfolio

The economic potential in 2035 is estimated to be an annual saving of 45,514 GWH (or 31% of the total electricity use in 2035). The largest portion of the savings is from the commercial sector, which accounts for 55% of the savings, while the residential and industrial sectors accounts for 32% and 13% respectively (illustrated in Figure 8-1).

Figure 8-1: Economic Potential Persistent Savings by Sector in 2035



8.2.2 Residential Sector

In the residential sector, the largest economic potential is estimated for the single family subsector, which accounts for 77% of the residential persistent savings in 2035 (as illustrated in Figure 8-2). Close to 70% of the estimated persistent savings in 2035 are from four end uses: lighting (27%), domestic hot water (20%), space cooling (13%) and space heating (11%) (see Figure 8-3).

Figure 8-2: Economic Potential Persistent Savings by Residential Subsector in 2035

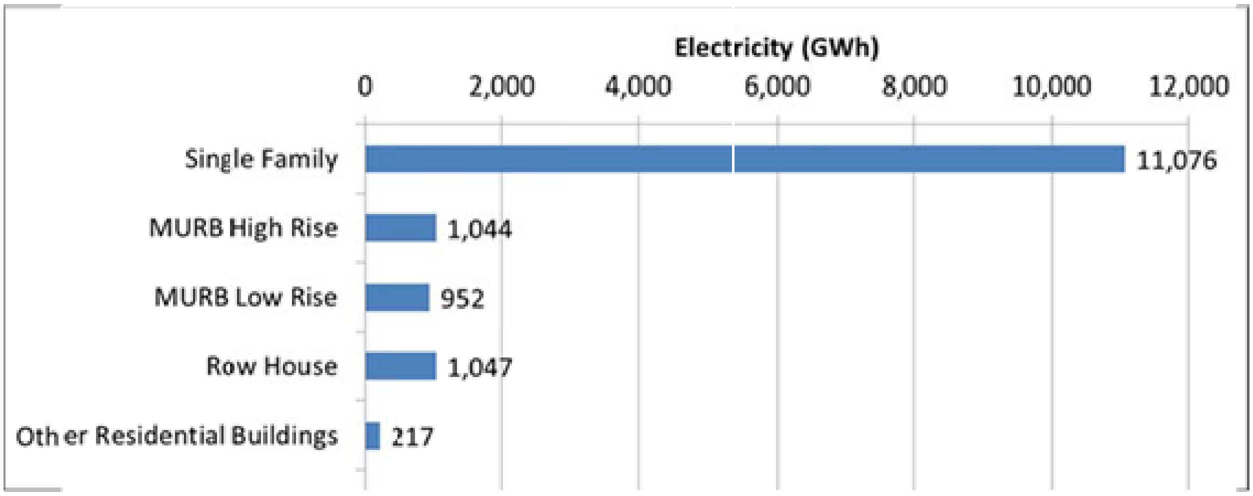
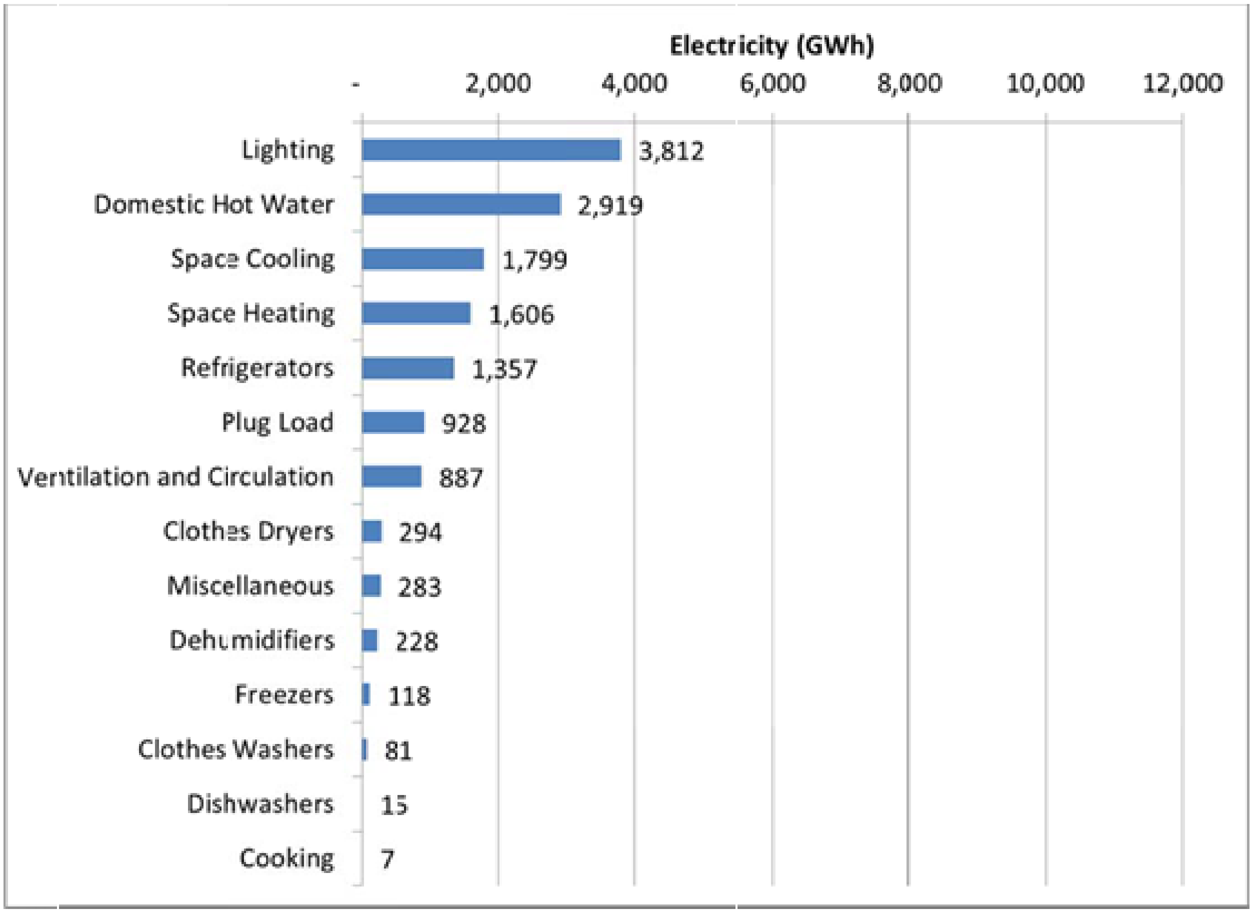


Figure 8-3: Economic Potential Persistent Savings by Residential End Use in 2035



8.2.3 Commercial Sector

In the commercial sector, five subsectors account for close to 65% of the persistent savings in 2035: other commercial buildings (17%), small office (15%), multi-unit residential common areas (11%), large office (11%), and TCU (10%) (see Figure 8-4). The lighting interior end use is estimated to result in 40% of the commercial sector's persistent savings in 2035. Other notable end use savings result from HVAC ventilation (15%) and cooling DX (12%) (illustrated in Figure 8-5).

Figure 8-4: Economic Potential Persistent Savings by Commercial Subsector in 2035

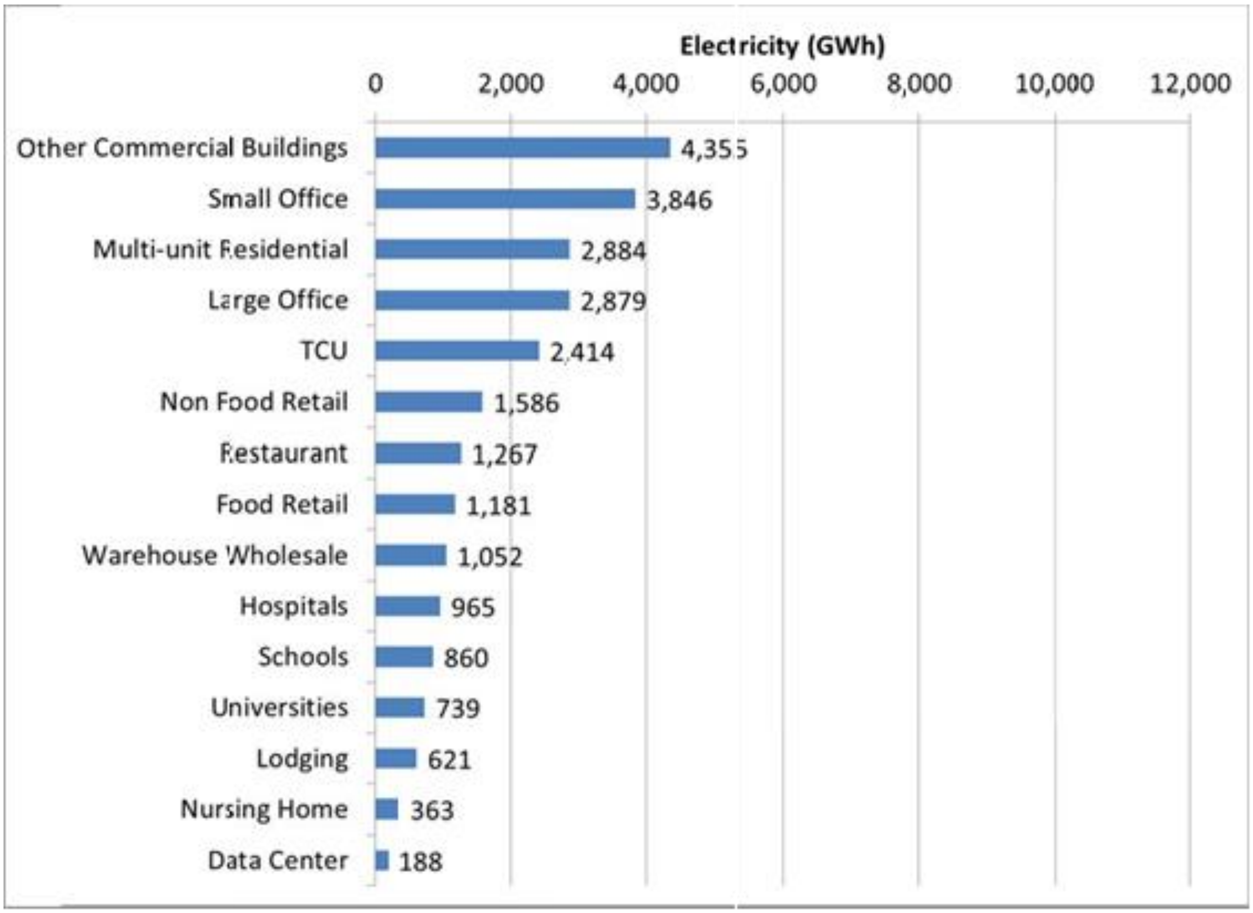
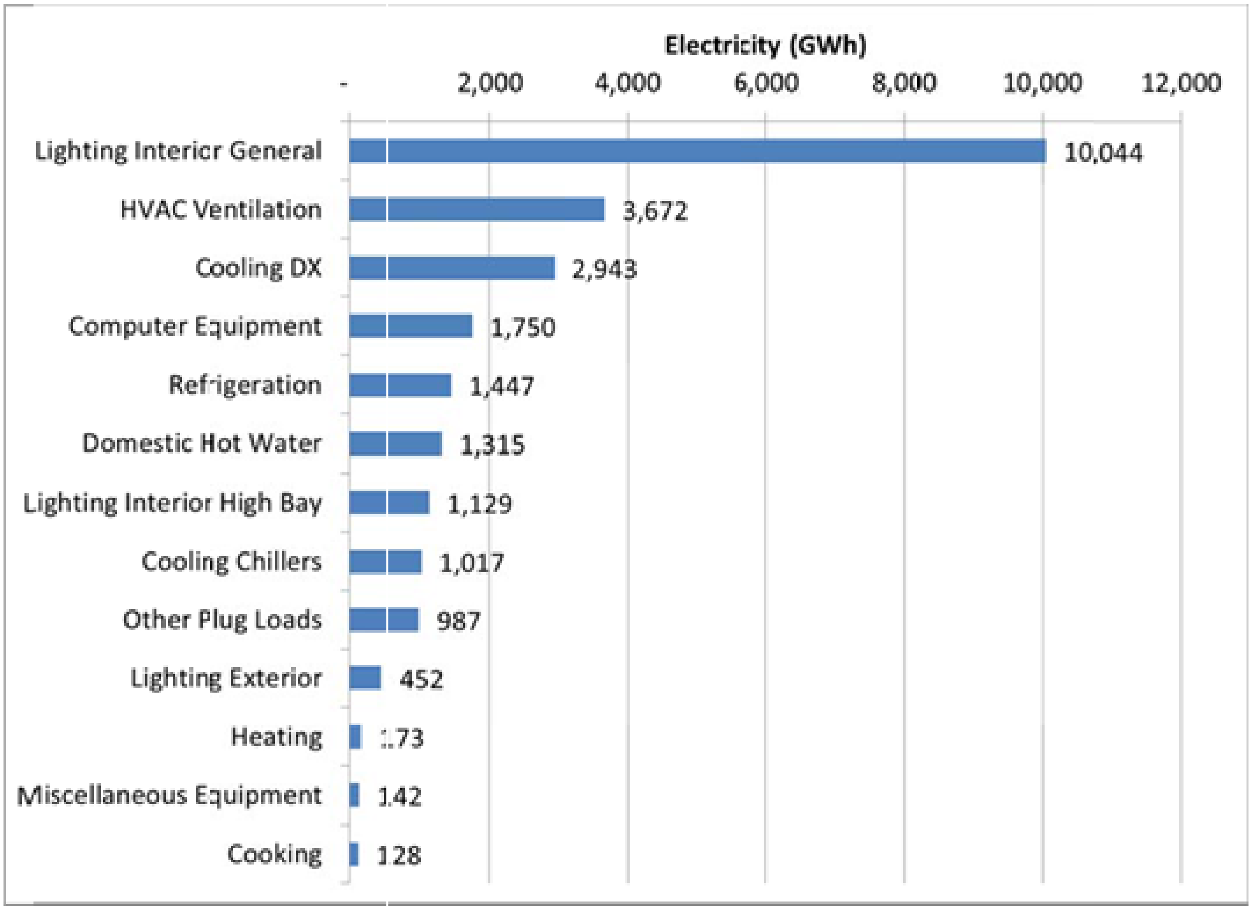


Figure 8-5: Economic Potential Persistent Savings by Commercial End Use in 2035



8.2.4 Industrial Sector

In the industrial sector, four subsectors each account for more than 10% of the persistent savings in 2035: mining (16%), chemical manufacturing (13%), auto parts manufacturing (12%) and primary metals (10%) (see Figure 8-6). HVAC is estimated to account for close to 24% the industrial sector's persistent savings in 2035 in the industrial sector, with other notable savings contributed by lighting (19%) and compressed air (18%) (illustrated in Figure 8-7).

Figure 8-6: Economic Potential Persistent Savings by Industrial Subsector in 2035

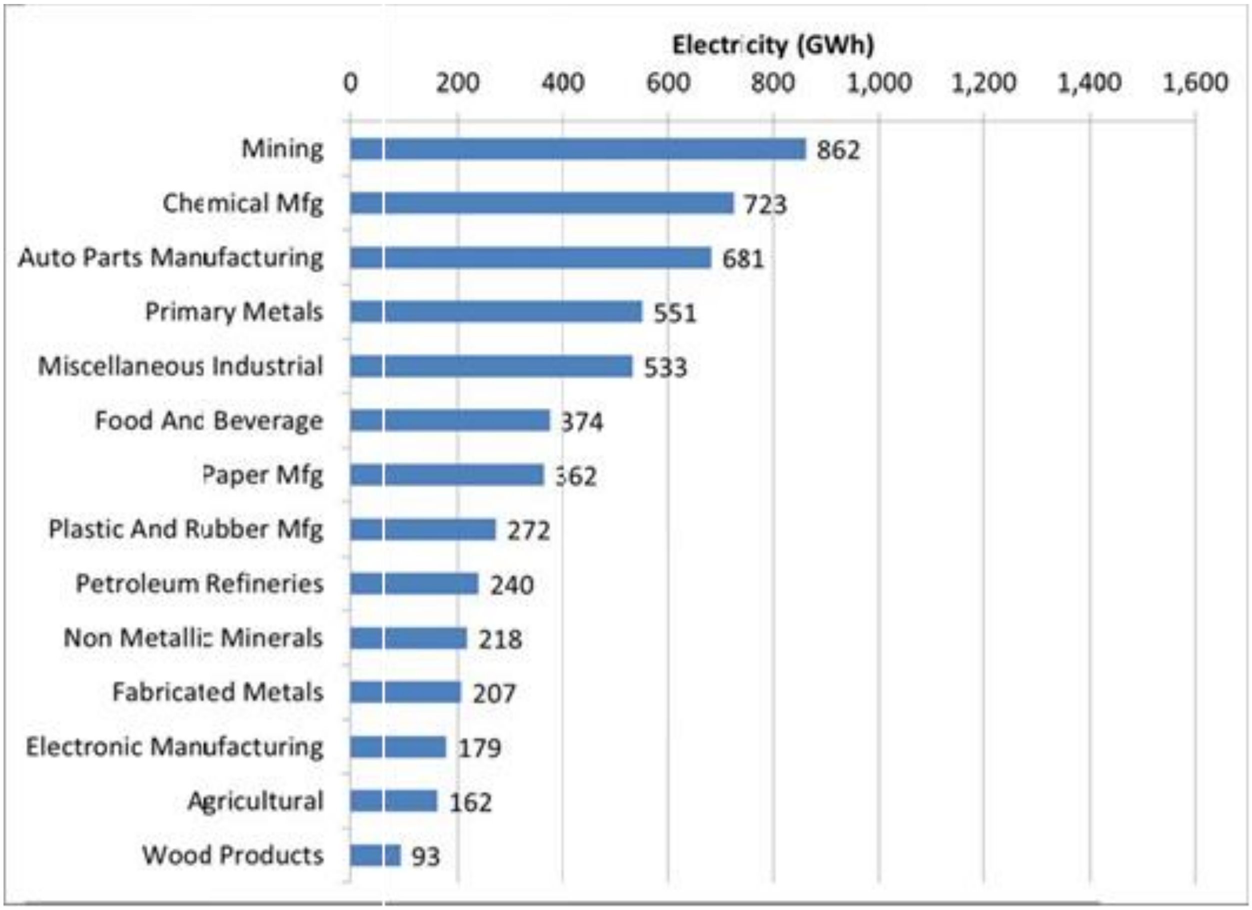
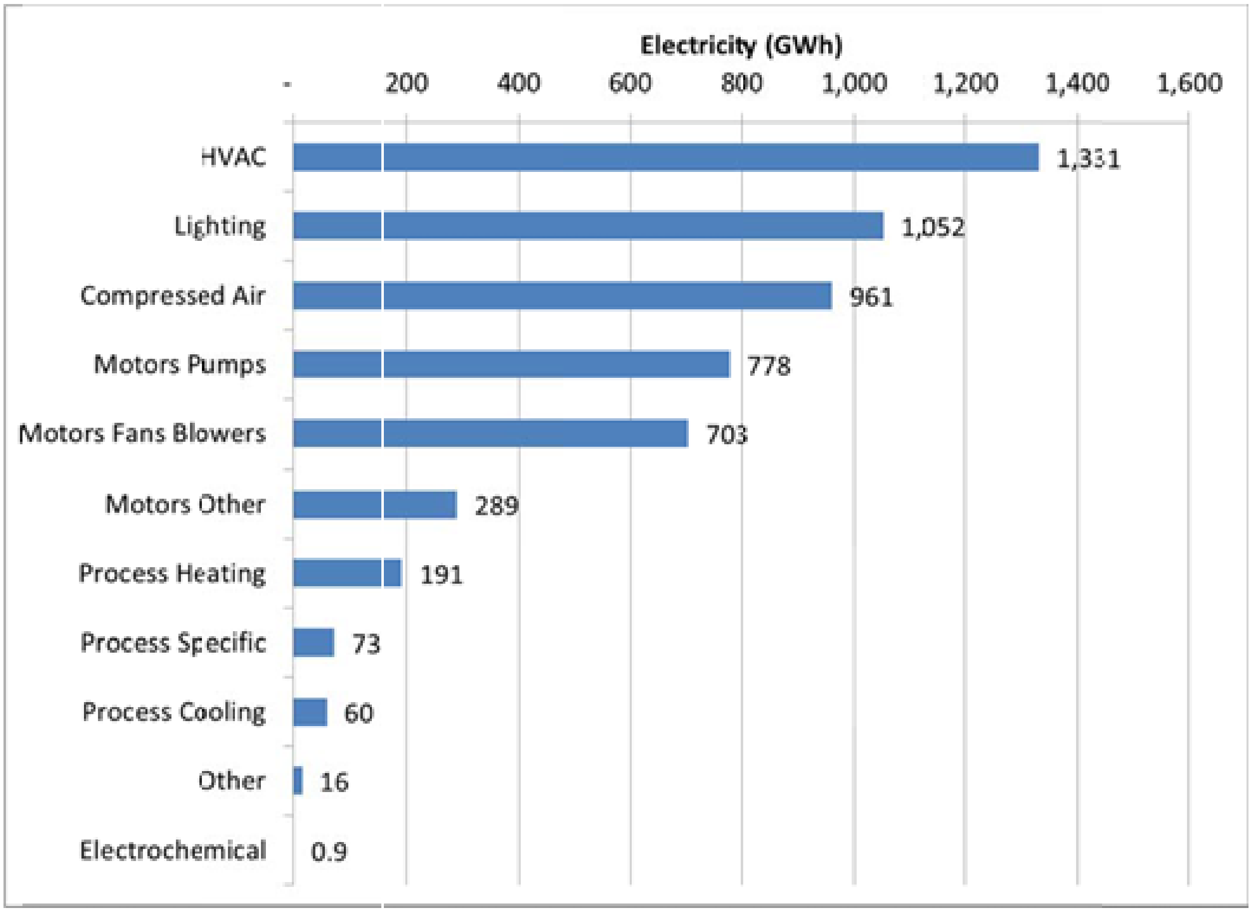
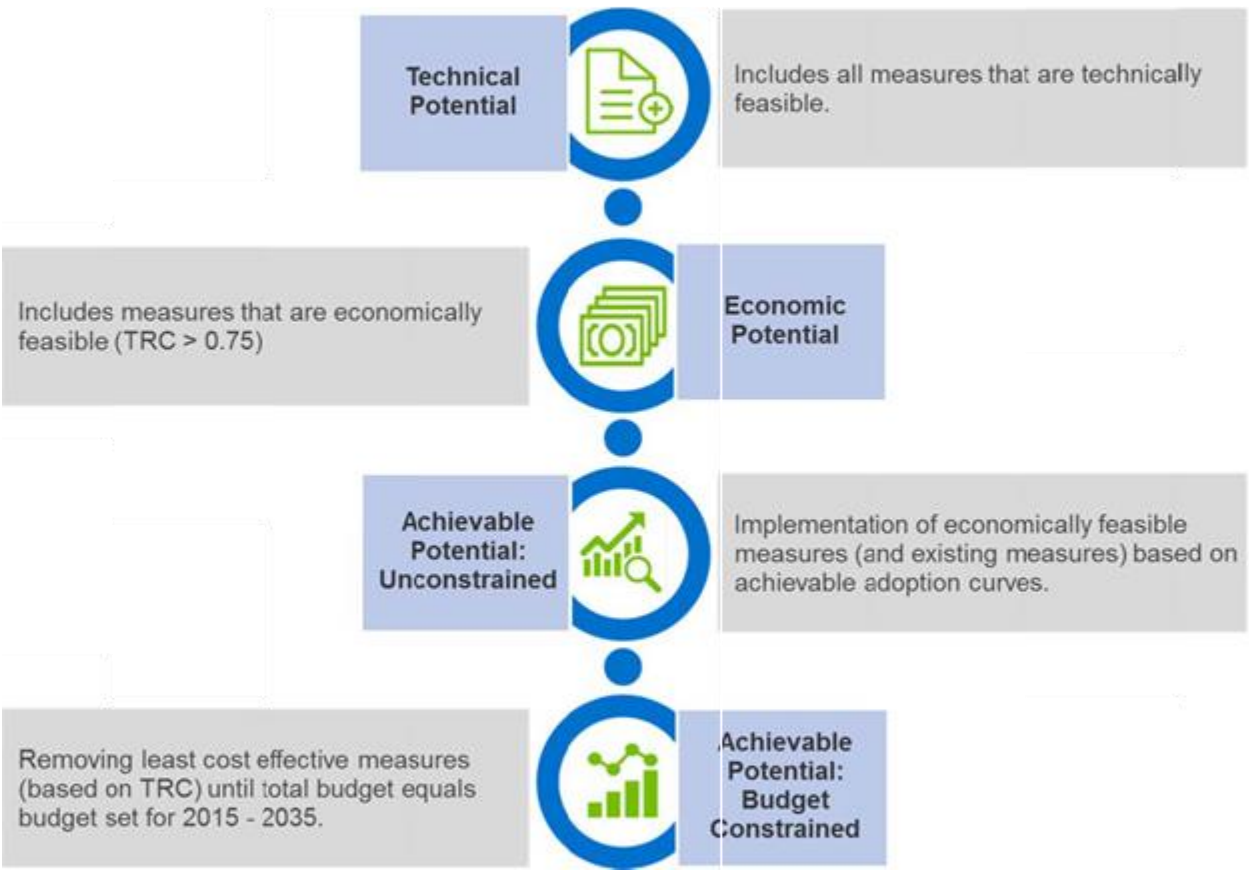


Figure 8-7: Economic Potential Persistent Savings by Industrial End Use in 2035



9 Achievable Potential Scenarios

In Section 8, the economic potential was estimated, which included only cost-effective measures. All the measures that were included in the economic potential scenario were included in the analysis of achievable potential scenario. The achievable potential scenario, addressed in this section, takes into consideration the adoption of cost-effective measures overtime. Two achievable potential scenarios are assessed: a budget unconstrained scenario and a budget constrained scenario. The subsequent section (Section 10) provides additional analyses, which includes a comparison of the potential savings with the baseline and reference case up to 2035, sensitivity analyses, and a comparison with actual savings achieved in other North American jurisdictions.



9.1 Methodology

Assessing achievable energy efficiency potential requires estimating the rate at which cost-effective archetype programs will be adopted over time. The following key items were considered and addressed in developing the methodology:

- Development and application of representative adoption curves.
- Mapping of measures to adoption curves.
- Historic performance of programs in each LDC's territory.
- Non-incentive program enhancements.
- Inclusion and exclusion of measures.
- The introduction of new technologies over a long term period.

The development of the achievable potential scenario builds on the economic potential scenario, by applying adoption curves to the measures that were included in the economic potential. Adoption curves are used to estimate the achievable annual participation in programs, or the annual take up of measures due to programs, from 2015 to 2035. In essence, adoption curves represent the percentage of participation of eligible customers in a program. The methodology used to develop the adoption curves is described in detail in Appendix C: Methodology to Calculate Achievable Potential.

Twenty-two adoption curves were developed for the residential sector and six adoption curves for the non-residential sector (i.e. commercial and industrial sectors), as discussed in Appendix C: Methodology to Calculate Achievable Potential. All the measures included in the economic potential scenario were mapped to the appropriate adoption curve. This mapping together with a detailed discussion and example of the steps to calculate the savings are included in Appendix C: Methodology to Calculate Achievable Potential. These steps include:

- Using IESO zone load profiles (see Section 5) and kWh load forecasts (see Section 6), a baseline forecast by sector, subsector, end use, equipment type, and vintage[6] was developed for each IESO zone.
- Using Ontario market adoption equations with IESO zone specific historic program participation to develop IESO zone specific adoption curves.
- Mapping of measure vintage permutations and their parameters to subsector, end use and equipment type. Measure research defined the parameters (such as: measure savings, cost and measure life) and is discussed in Section 4. The mapping results in defining competition groups (i.e. measures that are applicable to the same equipment

[6] The vintage indicates whether the stock falls into one of the following categories:
- New: Based on growth rates.
- Turnover: Based on average measure life for equipment type.
- Early retirement: Based on a factor of 0.5% of stock.
- Remaining: Portion remaining after subtracting other vintages from total.

type). For example, the “screw in lamp” equipment type has a number of energy efficient lamps that can be installed, which are defined as the competition group for the equipment type.

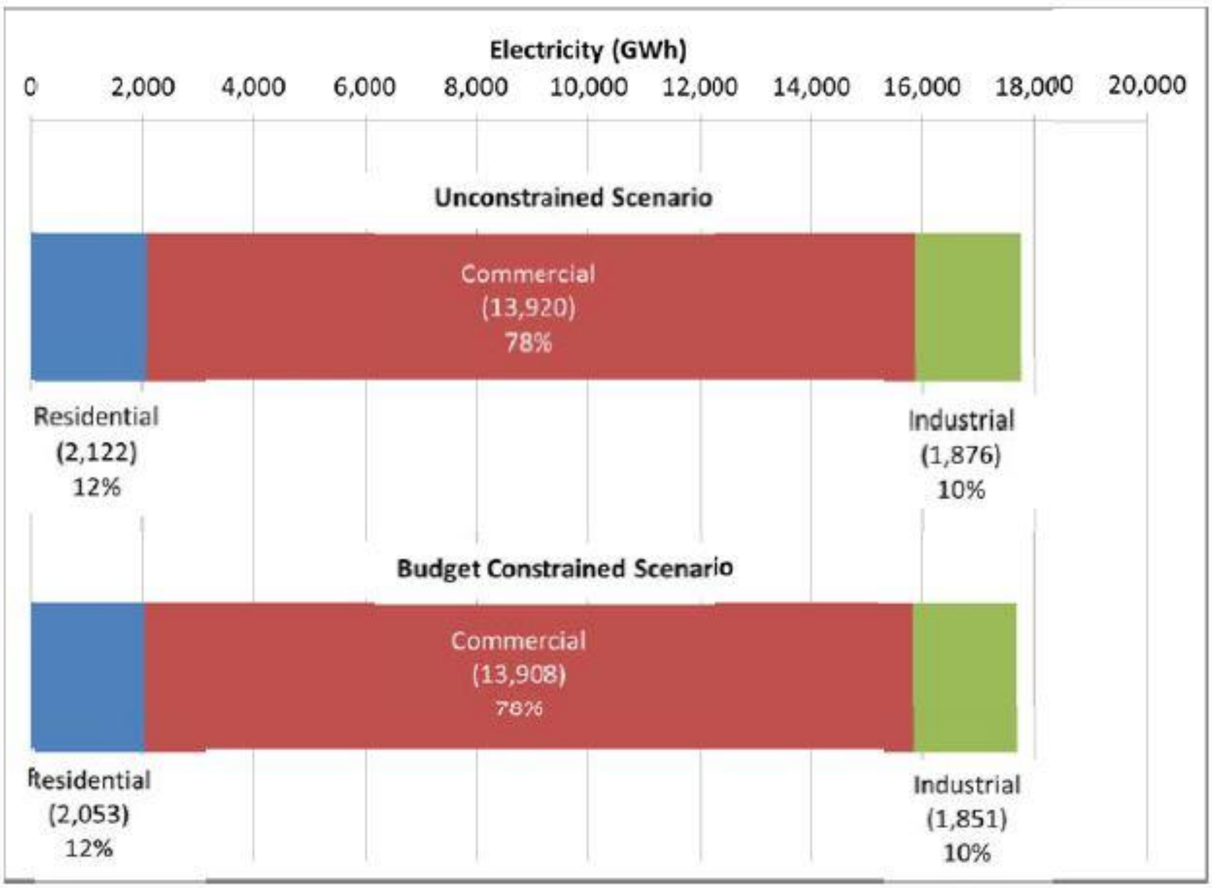
- Measures m pped to adoption curves and end uses.
- Measures in each vintage competition group ranked according to TRC.
- In each vintage group calculate savings for first ranked TRC. Remove this savings from available load for next measure in TRC ranking, to calculate savings for the next measure.
- Calculate the measure savings, which is the product of the load share, incremental adoption rate, measure applicability and savings of the measure. (See Appendix C: Methodology to Calculate Achievable Potential for an example and equations described in Section 7.
- In the budget unconstrained achievable potential scenario, the savings of all the measures are added up to provide end use savings for each IESO zone. The savings of all the IESO Zones are aggregated to determine the provincial savings potential.
- In the budget constrained achievable potential scenario the following steps were followed:
  - Rank measures (and their associated costs) for all sectors in order of cost-effectiveness (based on TRC).
  - Calculate the average annual budget for the LDC's CDM 2015-2020 budget, and use the average annual budget to determine the total budget for 2015 – 2035.
  - Identify all measures, in order of TRC ranking, which can be adopted for less than the total budget for 2015 - 2035.
  - Calculate the sum total of savings of these cost-effective measures to derive budget-constrained achievable potential for each end use per IESO zone.
  - The savings of all the IESO zones are aggregated to determine the provincial savings potential.

9.2 Results and Discussion

9.2.1 Portfolio

The achievable potential in 2035 is estimated to be an annual persistent saving of 17,918 GWh (or 12.1% of the total electricity use in 2035) for the unconstrained scenario and 17,810 GWh for the budget constrained scenario (or 12.0% of the total electricity use in 2035). The largest portion of the savings is from the commercial sector, which accounts for 78% of the savings, while the residential sector accounts for 12% in the unconstrained scenario, as illustrated in Figure 9-1.

Figure 9-1: Achievable Potential Persistent Savings by Sector in 2035



The portfolio cost effectiveness in terms of TRC and PAC by scenario is summarized in Table 9-1, while the acquisition cost analysis is summarized in Table 9-2. Comparing the TRC and PAC for the budget constrained achievable potential scenarios, the commercial and industrial sectors are relatively more cost effective compared to the residential sector. TRC for the commercial sector is 3.6, compared to 1.7 for the residential sector and 2.7 for the industrial sector.

The portfolio acquisition cost is estimated to be $ 308 / MWh for the budget constrained scenario. In the budget constrained scenario, the commercial sector has the lowest acquisition cost at $ 208 / MWH and the residential sector the highest cost at $ 961 / MWh.

Table 9-1Unconstrained Achievable Potential TRC and PAC Cost-Effectiveness (2015 – 2035)[7]

Archetype Program	TRC				PAC			
	NPV Costs ($ mil.)	NPV Benefits ($ mil.)	NPV Net Benefits ($ mil.)	TRC BC Ratio	NPV Costs ($ mil.)	NPV Benefits ($ mil.)	NPV Net Benefits ($ mil.)	PAC BC Ratio
Portfolio								
Technical	$55,768	$3,896	-$51,872	0.1	$14,130	$3,388	-$10,743	0.2
Economic	$795	$2,235	$1,440	2.8	$421	$1,943	$1,522	4.6
Achievable: Unconstrained	$327	$984	$657	3.0	$197	$856	$659	4.4
Achievable: Budget Constrained	$325	$978	$653	3.0	$195	$851	$656	4.4
Residential								
Technical	$3,617	$1,412	-$2,205	0.4	$2,170	$1,228	-$942	0.6
Economic	$423	$721	$298	1.7	$276	$627	$350	2.3
Achievable: Unconstrained	$87	$151	$64	1.7	$59	$132	$72	2.2
Achievable: Budget Constrained	$86	$147	$61	1.7	$58	$128	$70	2.2
Commercial								
Technical	$50,499	$2,169	-$48,330	0.0	$11,538	$1,886	-$9,652	0.2
Economic	$295	$1,260	$965	4.3	$112	$1,095	$984	9.8
Achievable: Unconstrained	$207	$744	$537	3.6	$117	$647	$530	5.5
Achievable: Budget Constrained	$207	$743	$537	3.6	$116	$646	$530	5.5
Industrial								
Technical	$1,652	$315	-$1,337	0.2	$423	$274	-$149	0.6
Economic	$80	$254	$177	3.3	$33	$223	$188	6.7
Achievable: Unconstrained	$33	$89	$56	2.7	$21	$77	$57	3.7
Achievable: Budget Constrained	$33	$88	$55	2.7	$21	$77	$56	3.7

[7] All cost values are based on net present value calculations.

Table 9-2 Unconstrained Achievable Potential Acquisition Cost (2015 – 2035)

Archetype Program	2015-2035 Program Costs ($ mil.)	2015-2035 Program Savings (MWh)	Acquisition Costs ($/MWh)
Portfolio			
Technical	$1,441,698	78,581,329	$18,347
Economic	$27,206	45,566,515	$599
Achievable: Unconstrained	$5,534	17,918,143	$309
Achievable: Budget Constrained	$5,479	17,810,563	$308
Residential			
Technical	$105,300	27,640,868	$3,810
Economic	$13,265	14,335,342	$925
Achievable: Unconstrained	$2,015	2,122,348	$949
Achievable: Budget Constrained	$1,972	2,052,641	$961
Commercial			
Technical	$1,293,046	43,483,765	$29,736
Economic	$10,957	25,199,525	$435
Achievable: Unconstrained	$2,905	13,920,292	$209
Achievable: Budget Constrained	$2,900	13,907,860	$208
Industrial			
Technical	$43,350	7,456,696	$5,814
Economic	$3,056	6,031,647	$507
Achievable: Unconstrained	$615	1,875,503	$328
Achievable: Budget Constrained	$607	1,850,061	$328

9.2.2 Residential Sector

Similar to the technical and economic potential scenarios, the largest achievable potential in the residential sector is estimated to be for the single family subsector, which accounts for 72% of the residential persistent saving in 2035 (as illustrated in Figure 9-2: Unconstrained Achievable Potential Persistent Savings by Residential Subsector in 2035 and Figure 9-3: Budget Constrained Achievable Potential Persistent Savings by Residential Subsector in 2035). The largest proportion of estimated persistent achievable potential savings in 2035 is from the lighting end use (55%), which is a relatively larger portion when compared to the economic potential scenario, where it accounted for only 27% of the residential savings.

Figure 9-2: Unconstrained Achievable Potential Persistent Savings by Residential Subsector in 2035

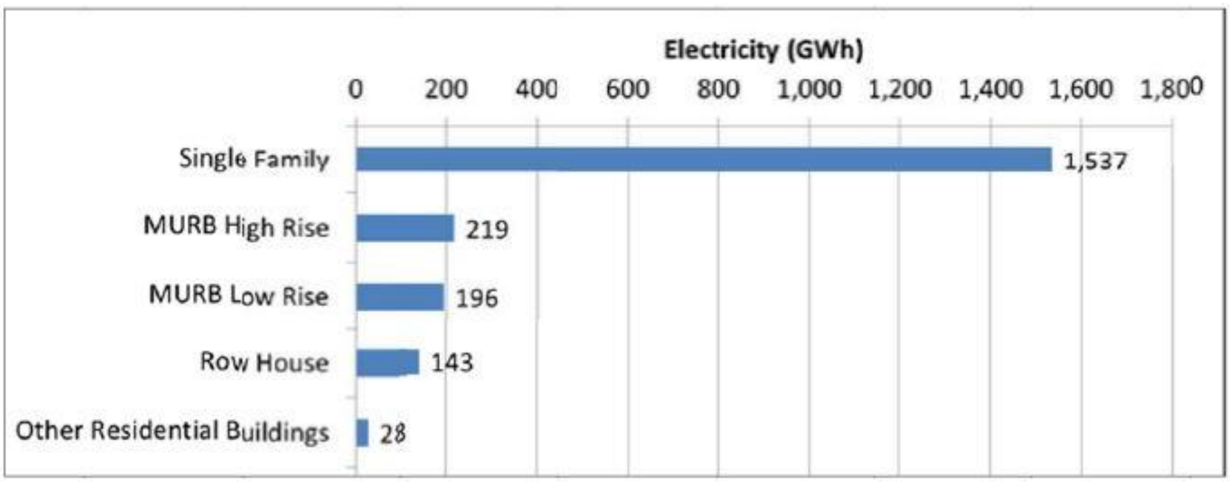


Figure 9-3: Budget Constrained Achievable Potential Persistent Savings by Residential Subsector in 2035

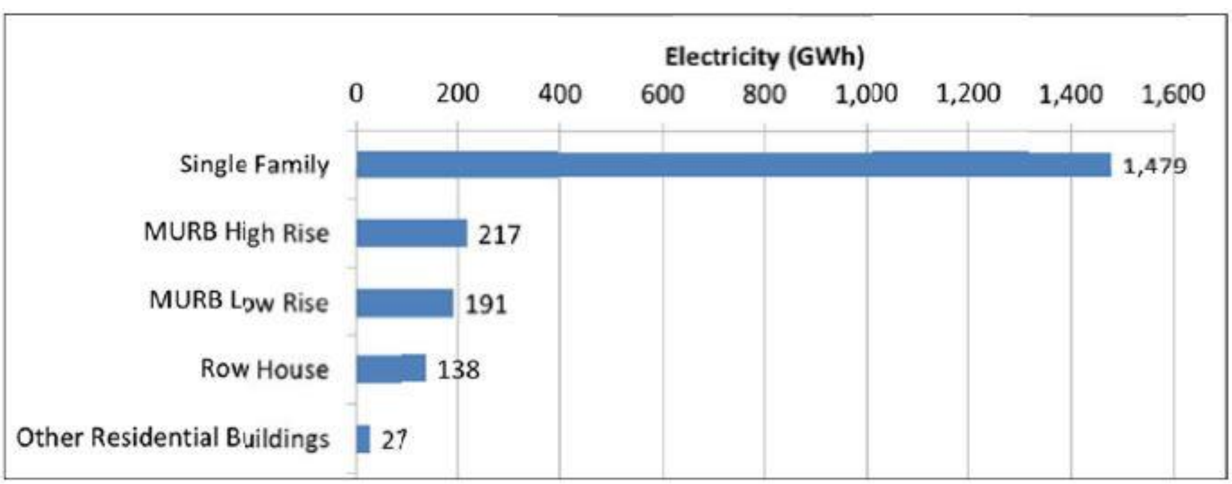


Figure 9-4: Unconstrained Achievable Potential Persistent Savings by Residential End Use in 2035

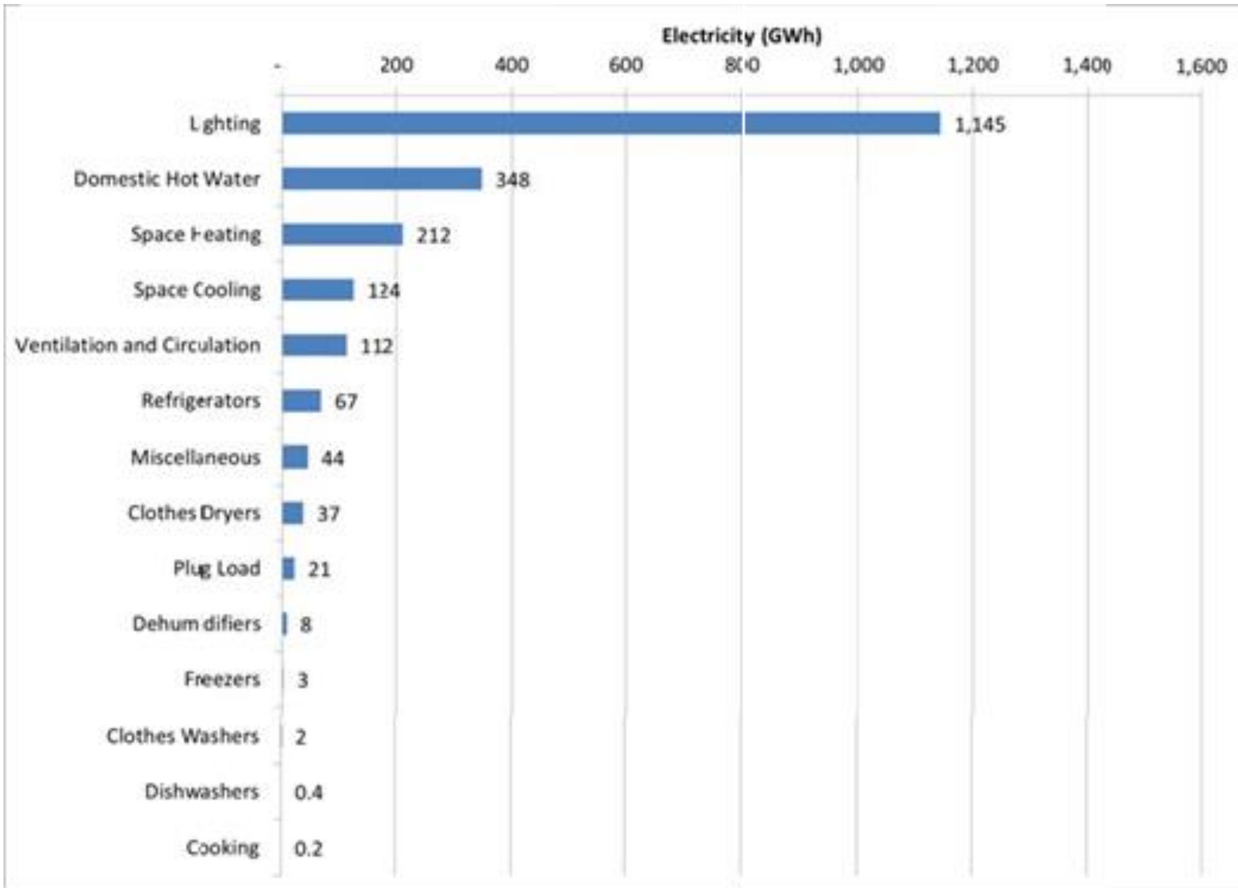
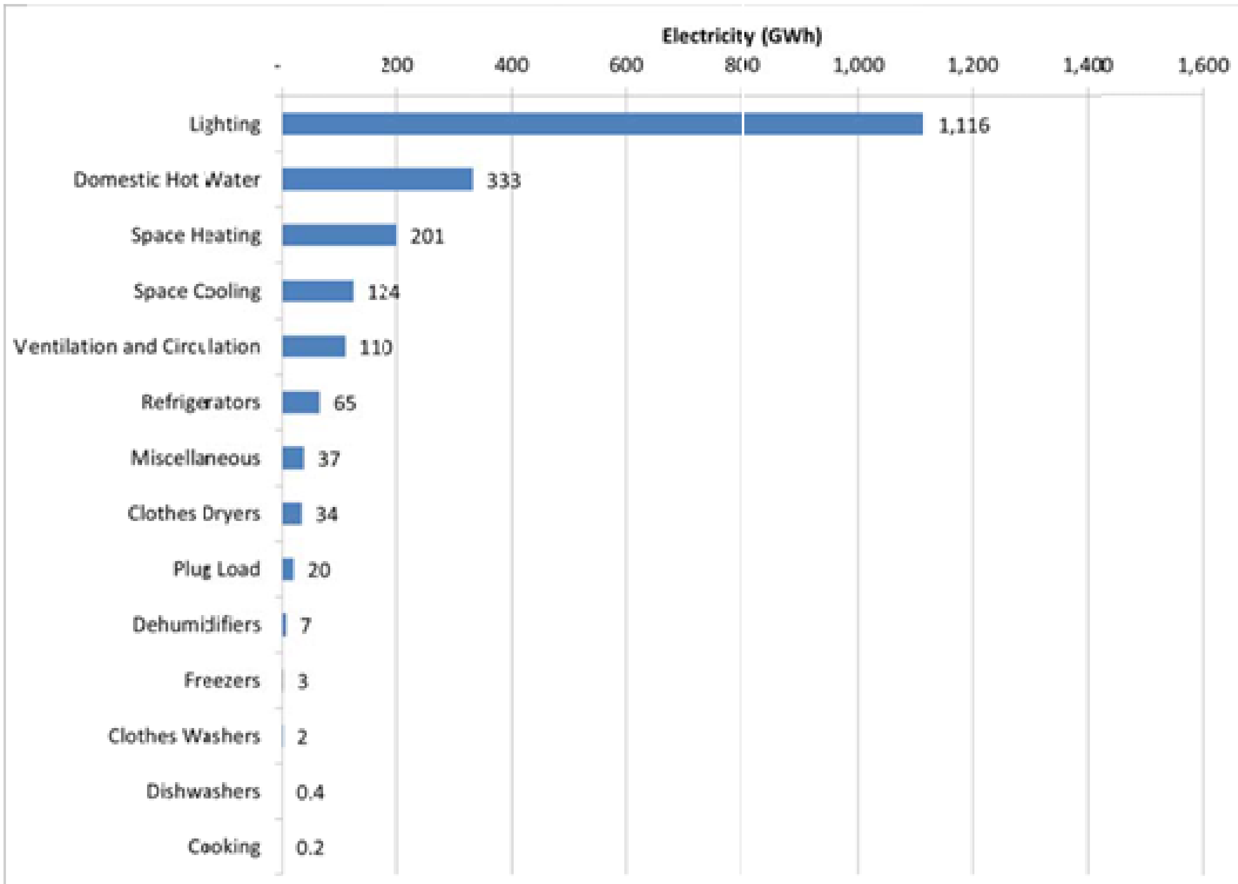


Figure 9-5: Budget Constrained Achievable Potential Persistent Savings by Residential End Use in 2035



9.2.3 Commercial Sector

The same five subsectors that contributed to the largest portion of the persistent savings in 2035 in the commercial sector's technical and economic potential scenarios, also contribute the largest portion of savings in the achievable potential scenarios: other commercial buildings (18%), small office (about 17%), large office (about 9%), TCU (9%), and multi-unit residential common areas (8%) (see Figure 9-6 and Figure 9-7). The lighting interior general end use is estimated to result in close to 49% the commercial sectors' persistent budget constrained achievable savings in 2035, compared to 40% in the economic potential scenario. In the achievable potential scenario, the portion of savings attributed to the lighting interior general end use and HVAC has increased slightly, while the savings of cooling DX end use has decreased slightly, as illustrated in Figure 9-8 and Figure 9-9.

Figure 9-6: Unconstrained Achievable Potential Persistent Savings by Commercial Subsector in 2035

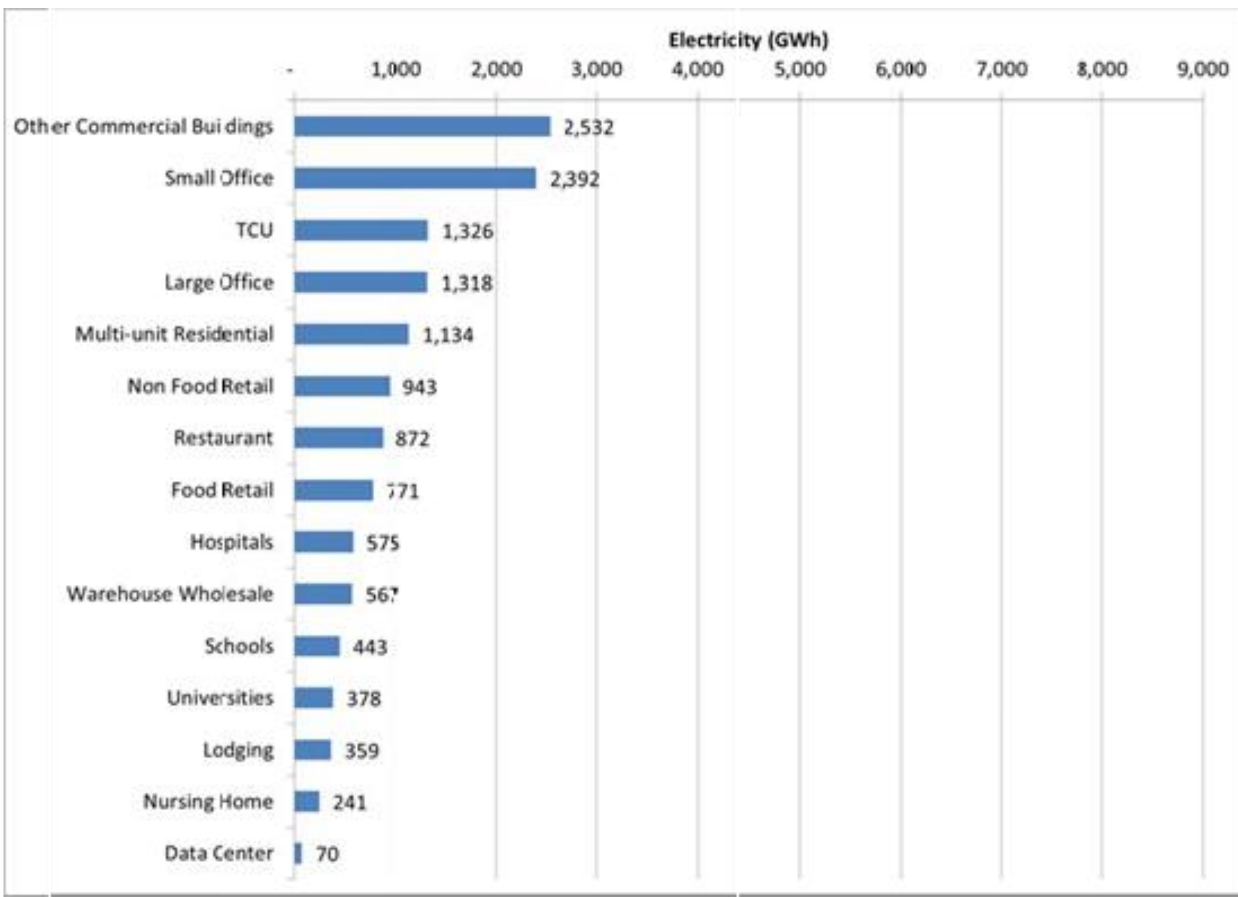


Figure 9-7: Budget Constrained Achievable Potential Persistent Savings by Commercial Subsector in 2035

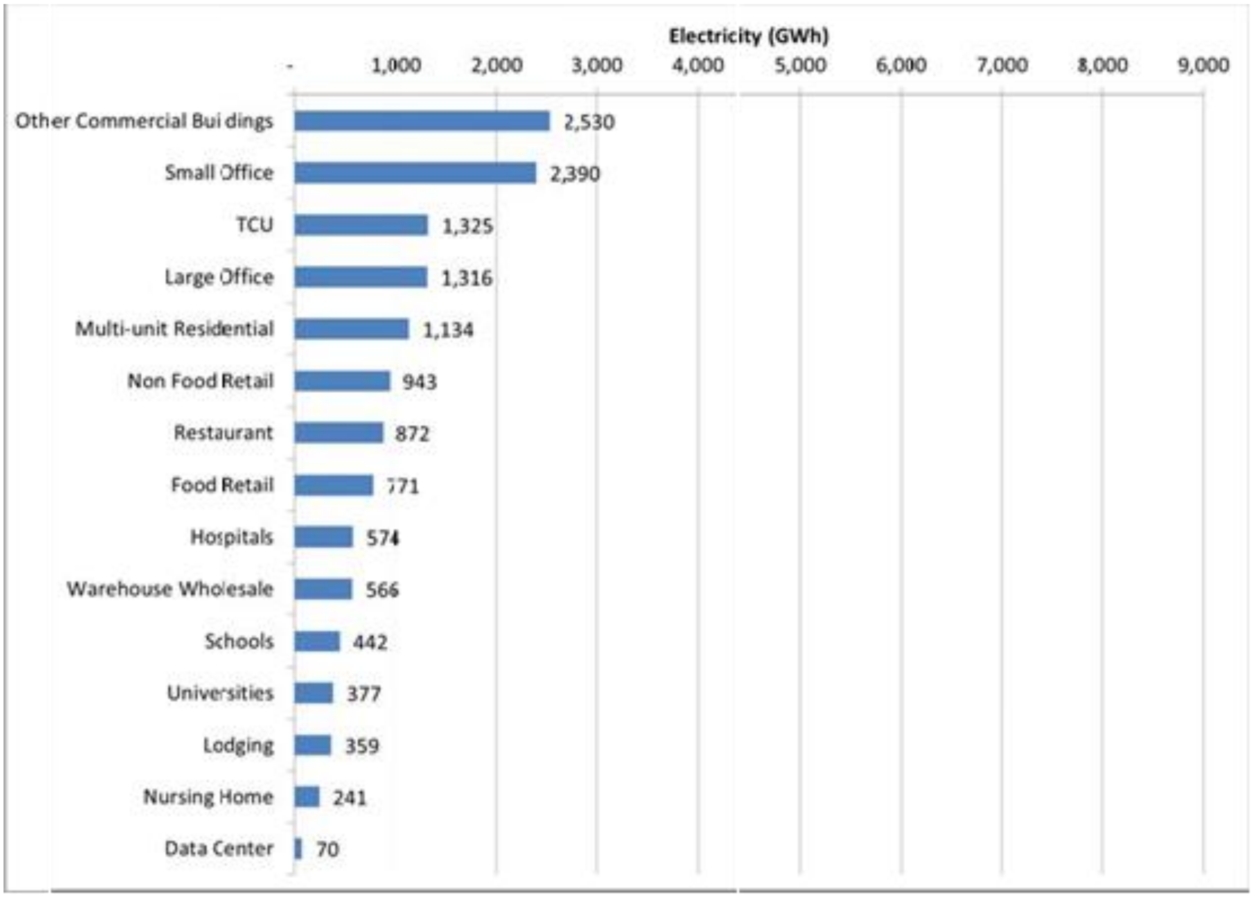


Figure 9-8: Unconstrained Achievable Potential Persistent Savings by Commercial End Use in 2035

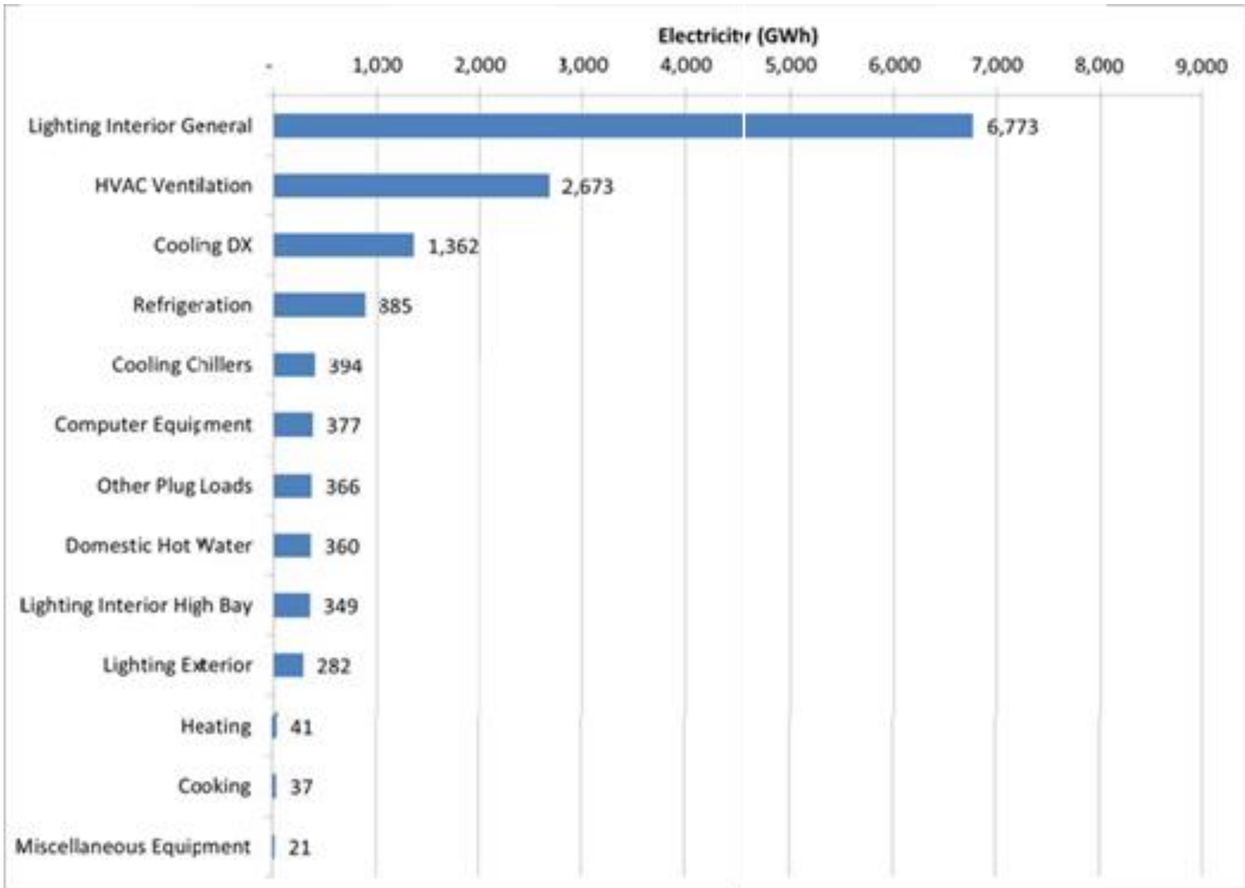
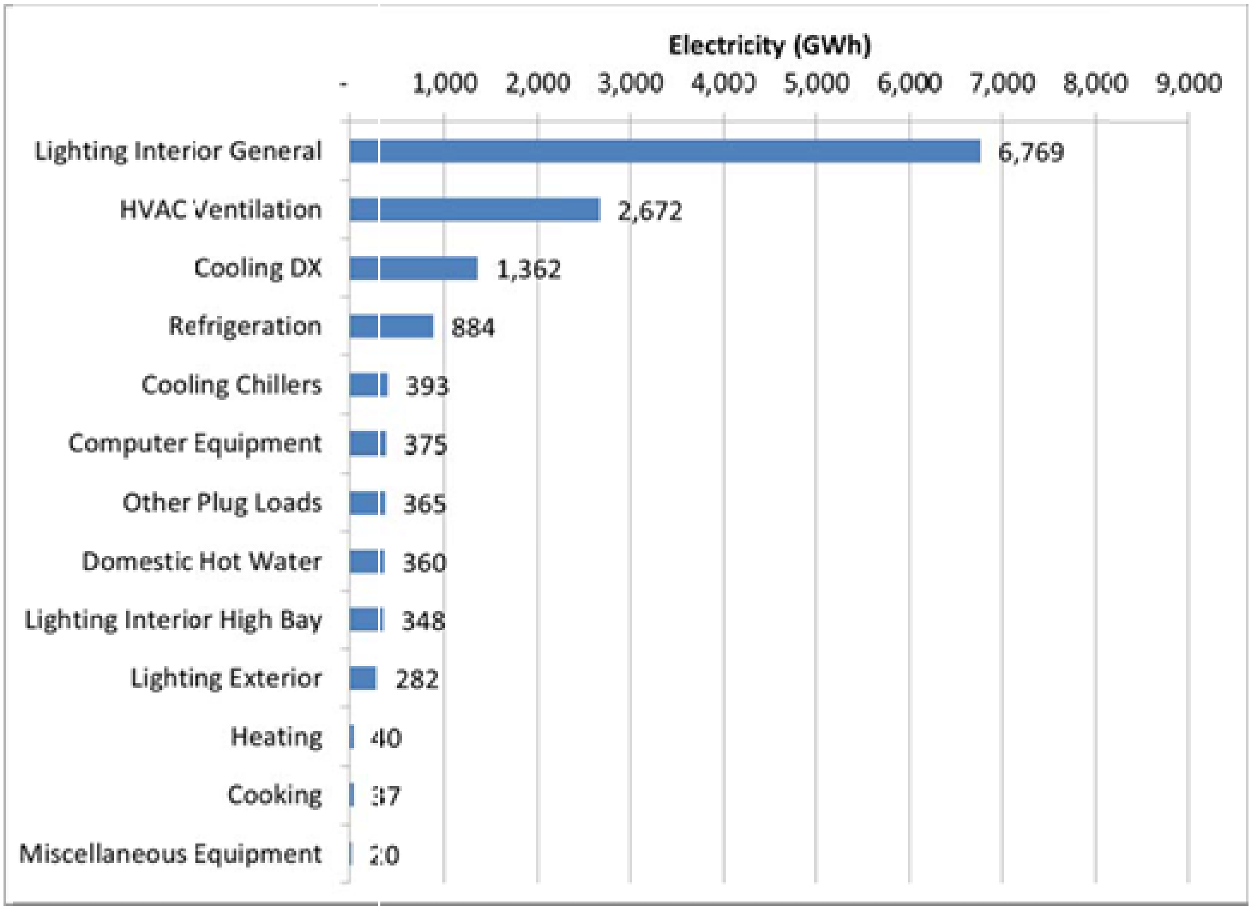


Figure 9-9: Budget Constrained Achievable Potential Persistent Savings by Commercial End Use in 2035



9.2.4 Industrial Sector

Similar to the findings in the economic potential scenario, four subsectors each account for more than 10% of the persistent achievable potential savings in 2035: mining (16%), chemical manufacturing (13%), primary metals (12%) and auto parts manufacturing (12%) (see Figure 9-10 and Figure 9-1). Lighting is estimated to account for close to 33% of the persistent savings in 2035, while other notable savings are contributed by HVAC (22%) and compressed air (13%) (see Figure 9-13). Comparing these end use percent savings with the technical and economic potential scenarios, a significant increase is observed for the lighting end use, and a slight decrease for the HVAC and compressed air end uses.

Figure 9-10: Unconstrained Achievable Potential Persistent Savings by Industrial Subsector in 2035

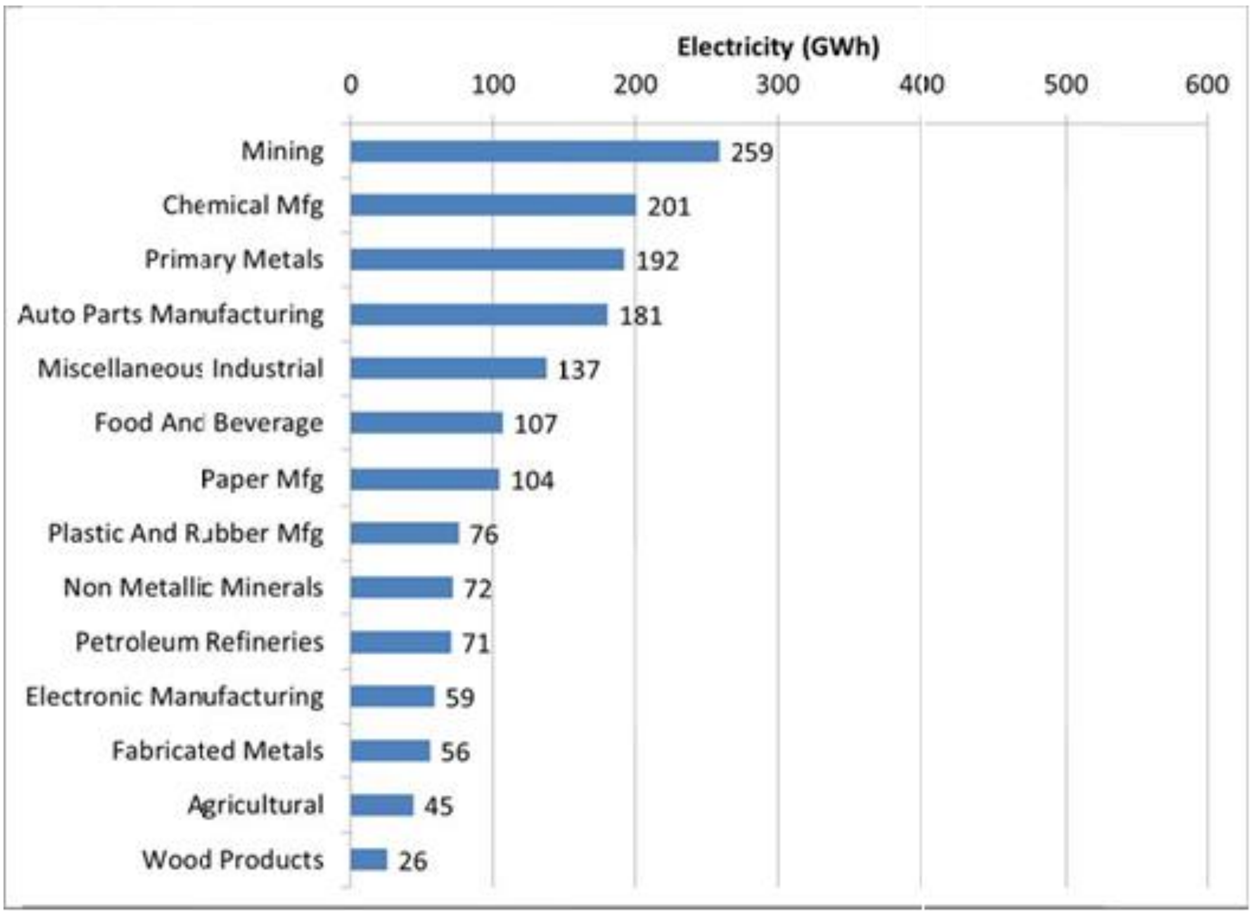


Figure 9-11: Budget Constrained Achievable Potential Persistent Savings by Industrial Subsector in 2035

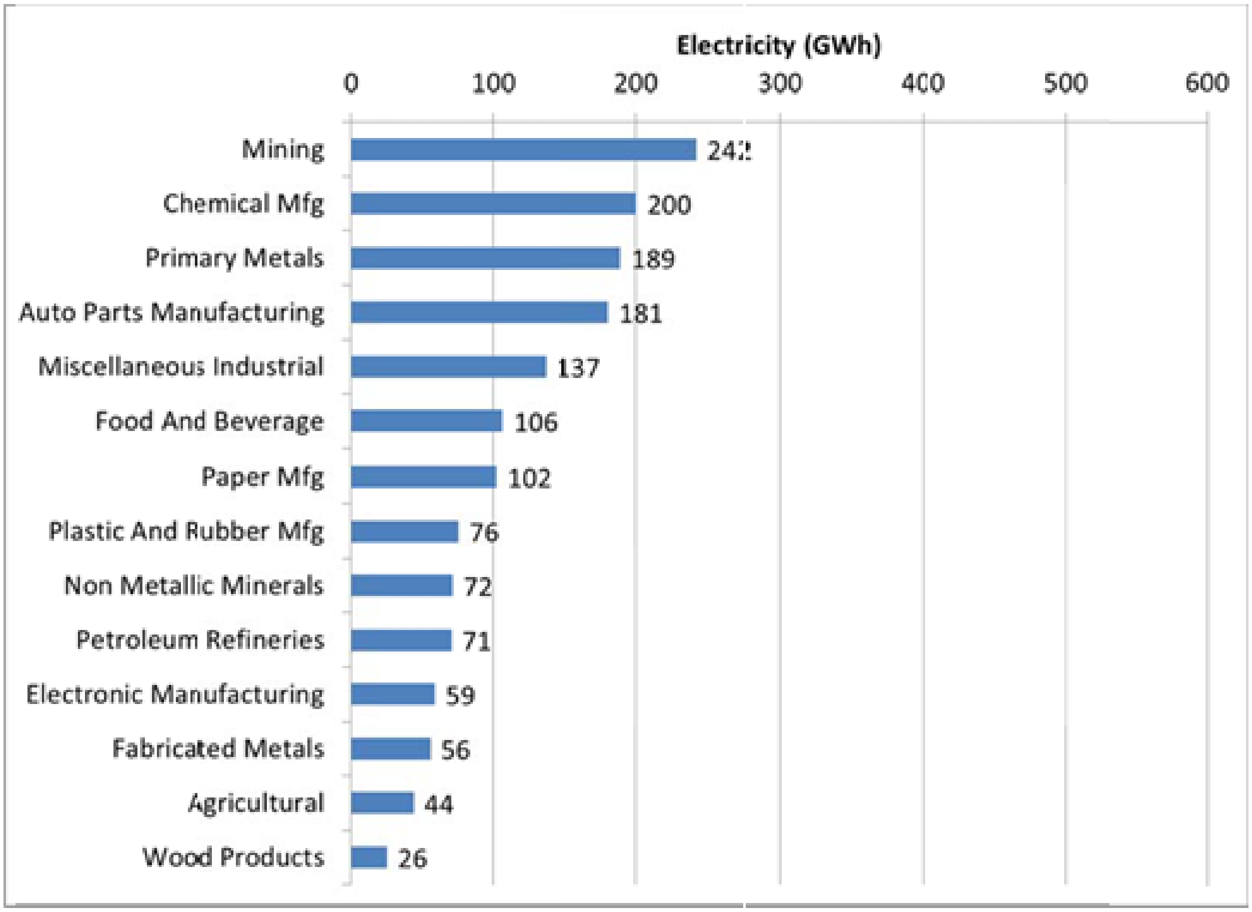


Figure 9-12: Unconstrained Achievable Potential Persistent Savings by Industrial End Use in 2035

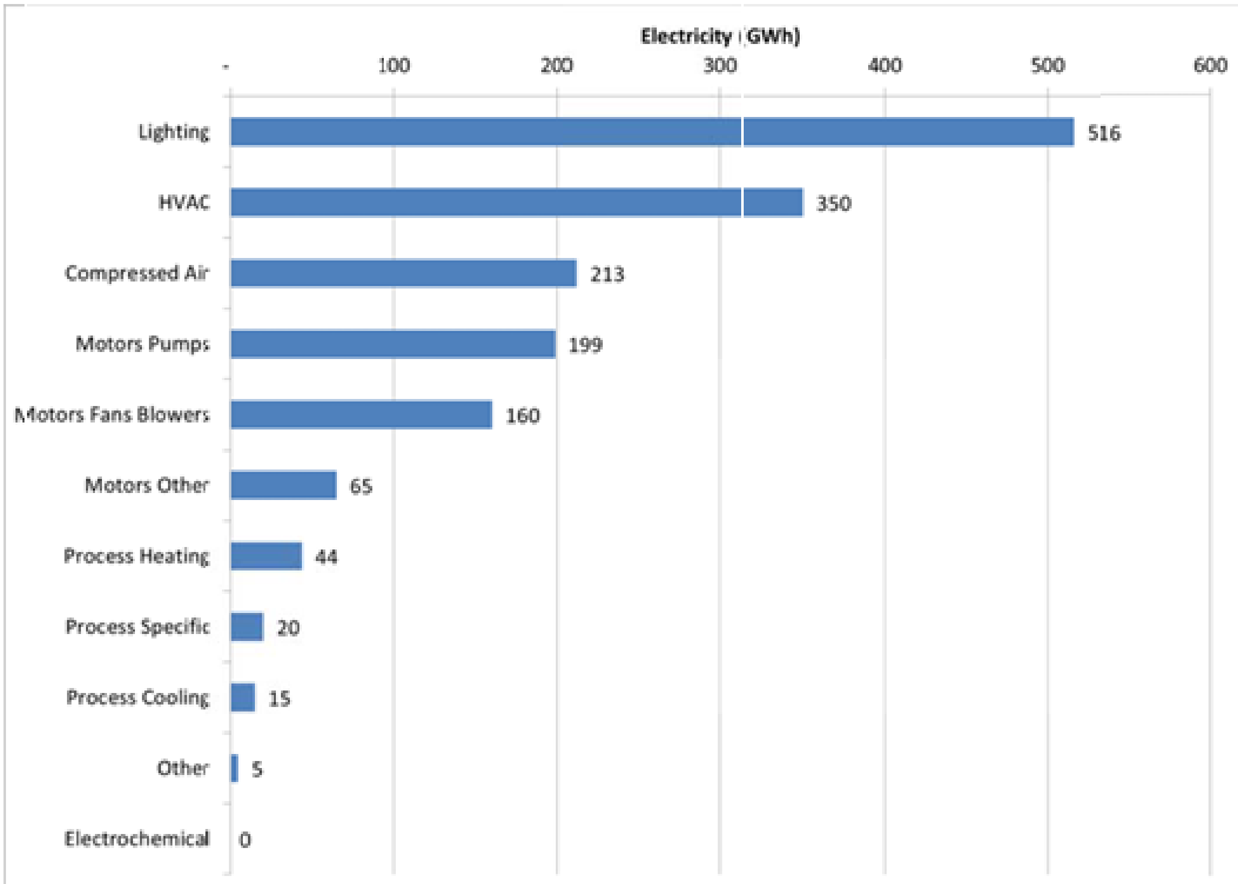
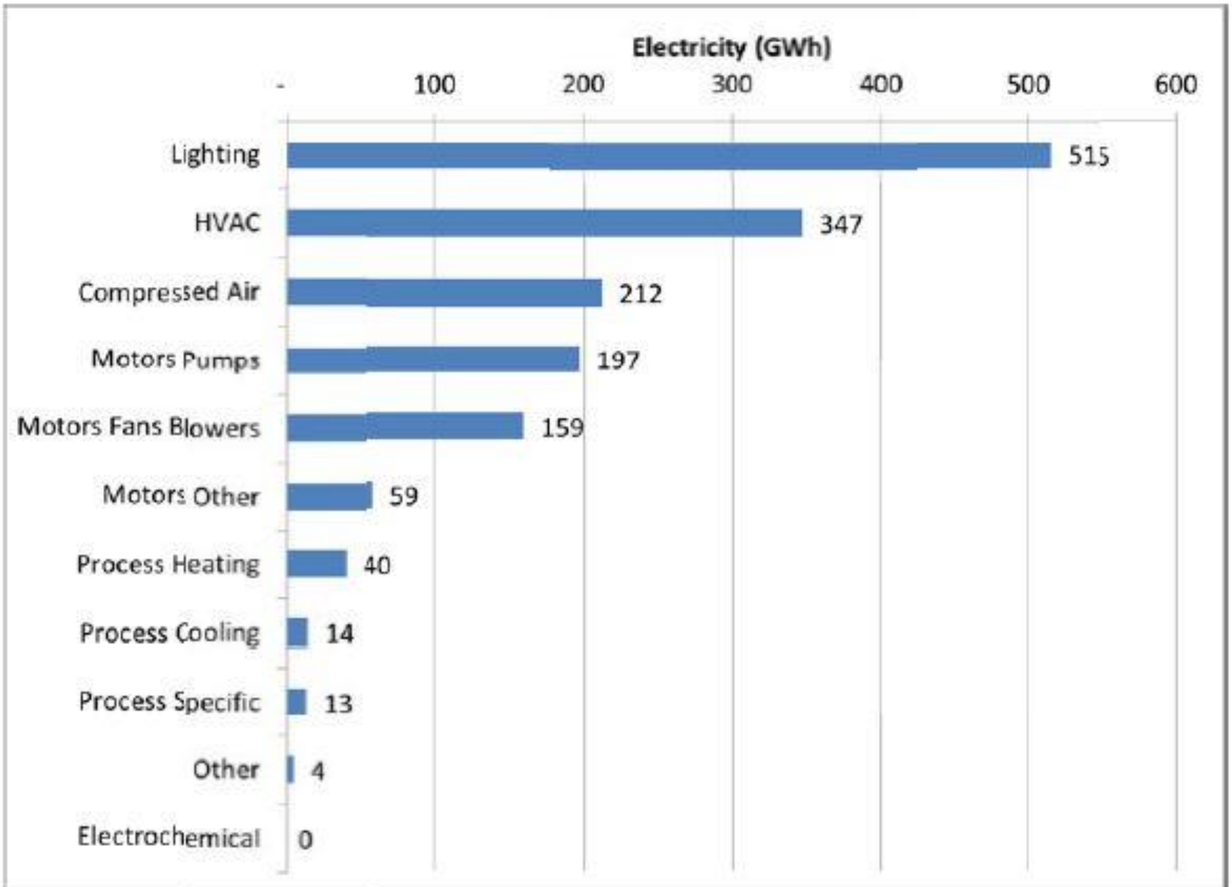


Figure 9-13: Budget Constrained Achievable Potential Persistent Savings by Industrial End Use in 2035



10 10 Additional Analyses

In the previous sections, the potential savings were estimated for four scenarios: technical, economic, unconstrained achievable and budget constrained achievable potential scenarios. This section includes additional analyses in which the potential savings are:

- Compared to the baseline and reference case forecast.
- Assessed to determine the sensitivity of the savings to changes in various input parameters.

Cost curves were also developed to illustrate the relationship of the cost to attain savings.

In the subsequent section (Section 11) recommendations are provided for future studies.

10.1 Potential Compared with Baseline and Reference Case Forecast

The comparison of the technical, economic and achievable potential scenarios with the baseline and reference case forecast is illustrated in Figure 10-1 and the electricity load values are summarized Table 10-1. The persistent savings in 2035 range from 53% for the technical potential to 12% for the budget constrained achievable potential when compared to the reference case forecast. The budget constrained achievable potential is 17,810 GWh in 2035 as summarized in Table 10-2.

Figure 10-1: Potential Scenarios Compared with Baseline and Reference Case

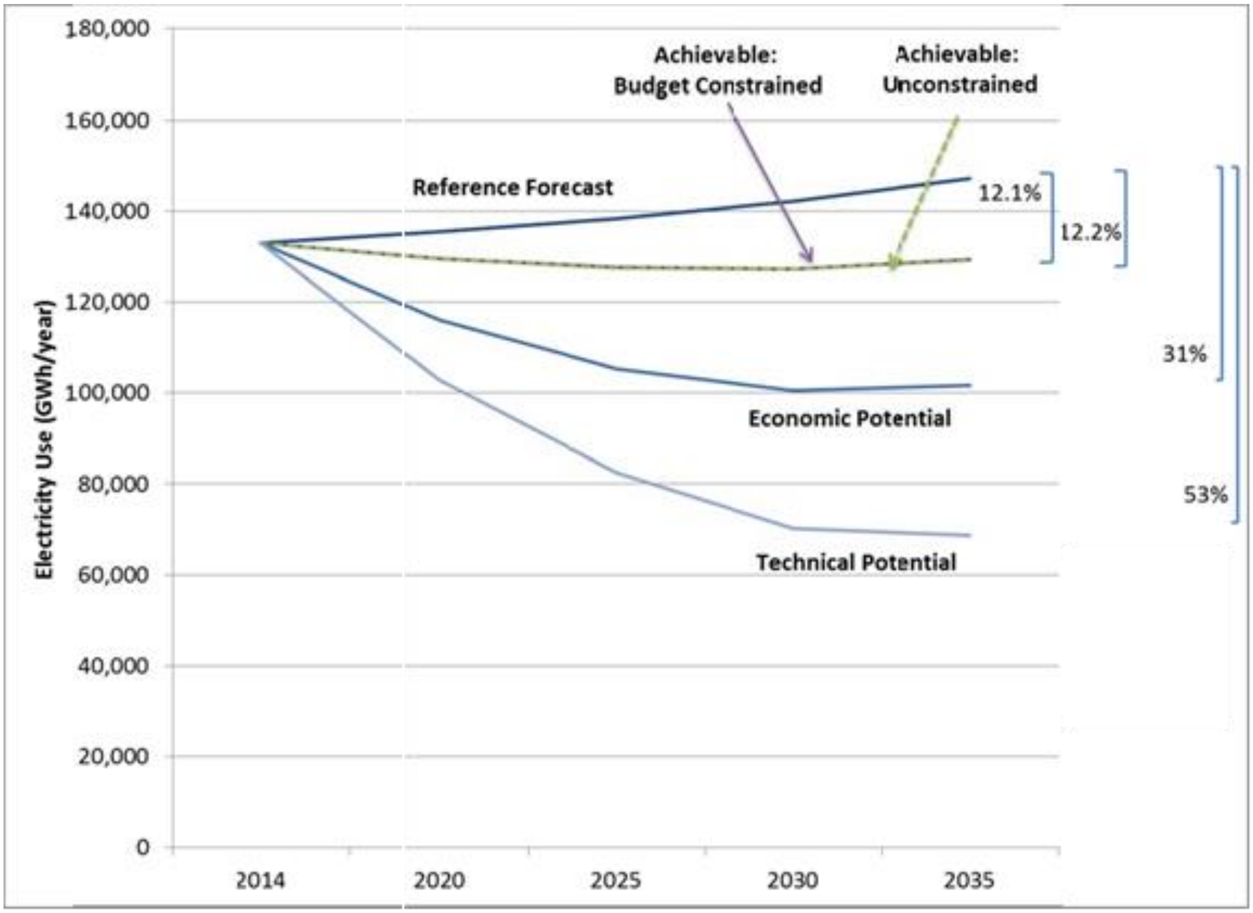


Table 10-1 Annual Electricity Use by Scenario for 2014 to 2035 (GWh/year)

Scenario	2014	2015	2020	2025	2030	2035
Base Year and Reference Case	133,022	130,329	135,562	138,328	142,129	147,147
Achievable Potential: Budget Constrained	133,022	129,708	129,575	127,523	127,282	129,336
Achievable Potential: Unconstrained	133,022	129,696	129,516	127,436	127,181	129,229
Economic Potential	133,022	126,983	116,081	105,338	100,451	101,633
Technical Potential	133,022	124,609	102,816	82,530	70,185	68,565

Table 10-2 Persistent Savings by Scenario in 2035 (GWh/year)

Scenario	2035
Technical Potential	78,581
Economic Potential	45,514
Achievable Potential: Unconstrained	17,918
Achievable Potential: Budget Constrained	17,810

10.2 Sensitivity Analysis

The objective of this task is to assess the impact on the achievable potential savings if key input parameters are changed. This provides an indication of how sensitive the results are to changes in input parameters. The long term potential analysis is based on the short term achievable potential analysis and the sensitivities will b changes in key input parameters had to be the same in both cases. The assessment of the one at the LDC level to determine the sensitivity to the adjustments. The sensitivity analysis and results are discussed in the report for the short term analysis and is repeated here for ease of reference.

Results from two LDCs were used in the sensitivity analyses:

- LDC 1: medium to large sized LDC with a relatively smaller portion of residential load.
- LDC 2: medium to large sized LDC with relatively larger portion of residential load.

The key input parameters that were assessed in the sensitivity analysis are:

- Incentive rates
- Adoption curves
- Avoided cost

The sensitivity analysis is discussed in the remainder of this section.

10.2.1 Incentive Rates

The following methodology was used to assess the impact on the achievable potential when incentive rates are changed:

- Incentive rates were increased +/- 25% for all archetype programs. The +25% incentive increase was not applied to archetype programs such as Low Income, since its incentive rate was already 100%.

- The price elasticity research conducted for this study was referenced. For commercial and industrial sectors the price elasticity value was found to be 0.46, while the residential sector price elasticity values was estimated at 0.25[8].
- The price elasticity values were utilized to establish the adjustment factor to be applied to the base case modelled savings estimates using the formula: Savings Factor Adjustment = 1+ (Price Elasticity Value x Incentive Change %).
    - For commercial and industrial sectors, the savings adjustment factor was estimated at 1.115 for +25% incentive adjustment and 0.885 for -25% incentive adjustment
    - For the residential sectors the savings adjustment factor was estimated at 1.0625 for +25% incentive adjustment and 0.9375 for -25% incentive adjustment
- The combination of the incentive rate adjustment and modelled savings adjustment was calculated to estimate a revised 2020 portfolio savings estimate. This result was compared against both the unconstrained achievable base case savings and the budget constrained base case savings.

The results from the analysis are illustrated in Figure 10-2 and Figure 10-3. The unconstrained scenario indicates that increasing or decreasing incentive rates will lead to proportional increases and decreases in savings.

The budget constrained scenario indicates that the portion of residential load affects the impact of increasing or decreasing the incentive rates. Due to the lower price elasticity for the residential sector, for an LDC with a relatively larger portion residential load, more money allocated to incentives does not translate into incrementally more savings.

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[8] Price elasticity is a basic measure of demand or supply sensitivity to changes in price. An elasticity value of 1.0 would indicate a product that is perfectly elastic: any change in price would result in drastic changes to supply and demand (in this case, supply and demand would drop to 0). An elasticity value of 0 indicates that changes to price have no effect on supply and demand. These extreme cases are often theoretical, or at least rare. More common elasticity values fall within the range of 0 to 1 and indicate a percentage change in quantity supplied or demanded for a given percentage change in price. Price is not the only factor that affects demand or supply. For example, in this study the elasticity for incentives is lower in the commercial sector than in the residential sector. Commercial customers are less sensitive to changes in incentives mainly due to the following reasons: time spent to evaluate energy efficiency product may represent time taken away from other, more valuable business activities. In short, other aspects of running the business may be more important than evaluating and identifying cost-effective energy savings measures. Residential customer, on the other hand, are likely to be more sensitive to price because there are more product options in the residential market and price is a more important consideration for limited household budgets.

Figure 10-2: Sensitivity to Changes in Incentive Rates - Unconstrained Achievable

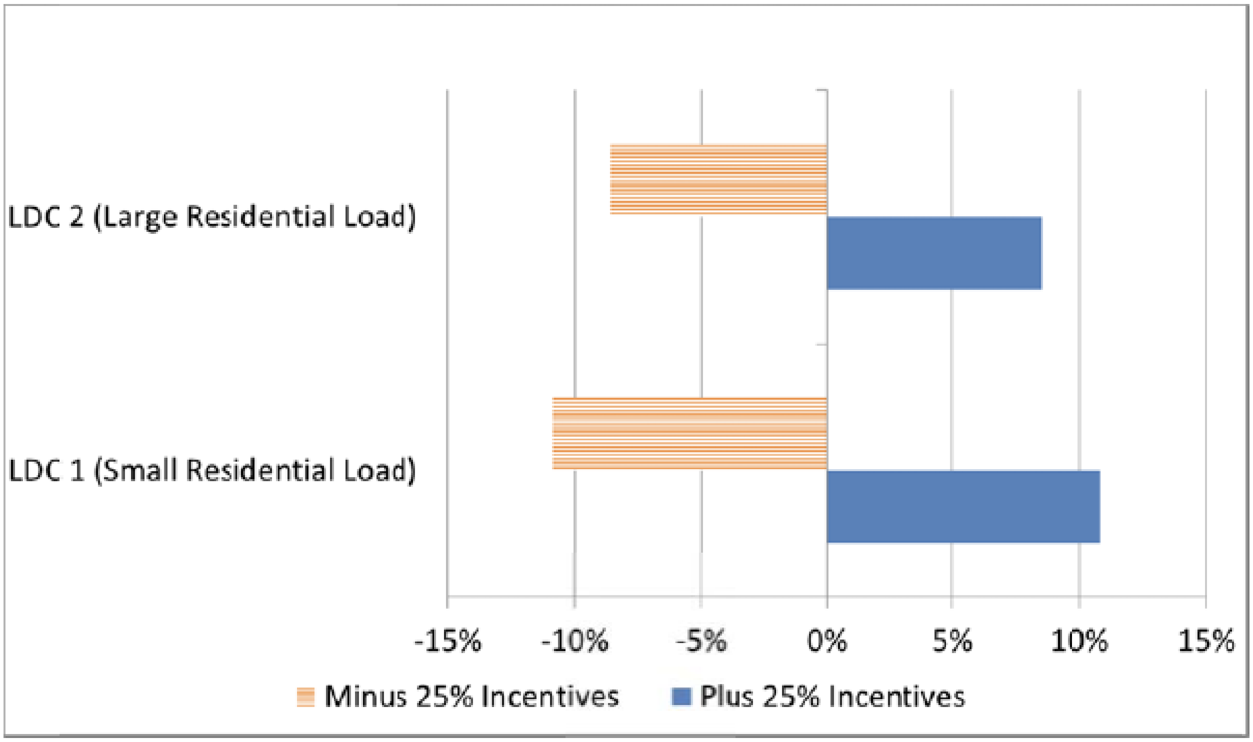
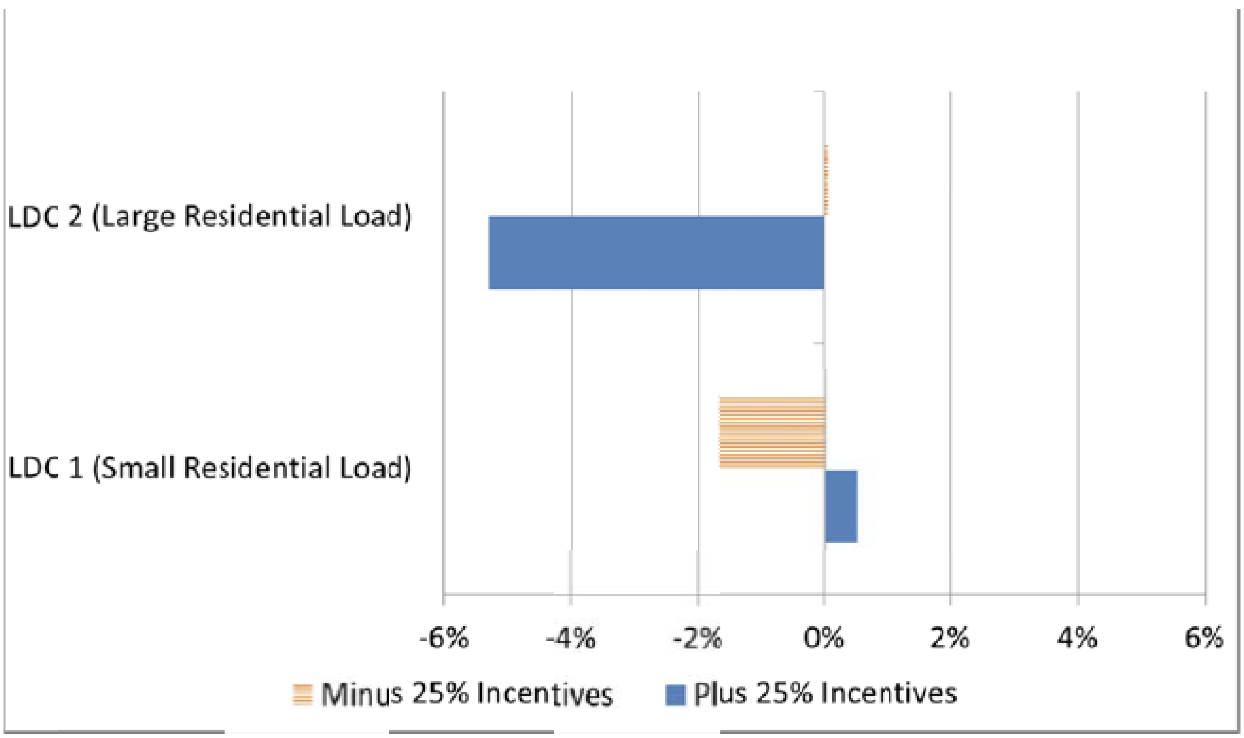


Figure 10-3: Sensitivity to Changes in Incentive Rates - Budget Constrained Achievable



10.2.2 Adoption Curves

A faster or slower participation in programs compared to the estimated adoption in this study, will result in a change in the adoption curves. The sensitivity of the estimated achievable potential to changes in the adoption curves was assessed. The following methodology was used to assess the impact on the achievable potential when adoption curves are changed:

- Adoption rates were revised by +/-25% across all measures for each year of the short term horizon.
- Incentive and program administrative costs were also revised in line with the calculated savings increase/decrease.
- The impact on 2020 portfolio energy savings were calculated and were compared with both unconstrained and budget constrained achievable potential base case scenarios.

Figure 10-4 and Figure 10-5 provide the results of the sensitivity analysis and indicate for both unconstrained and budget constrained scenarios, the increase or decrease in savings are relatively proportional to the changes in adoption rates. Increased adoption rates in the budget constrained scenario do have a significant lower impact on increased savings compared to the unconstrained scenario. A 25% increase in adoption rates result in an increase savings of between 6% and 8% in the budget constrained achievable potential scenario, compared to 23% to 24% for the unconstrained achievable potential scenario.

Figure 10-4: Sensitivity to Changes in Adoption Curves – Unconstrained Achievable

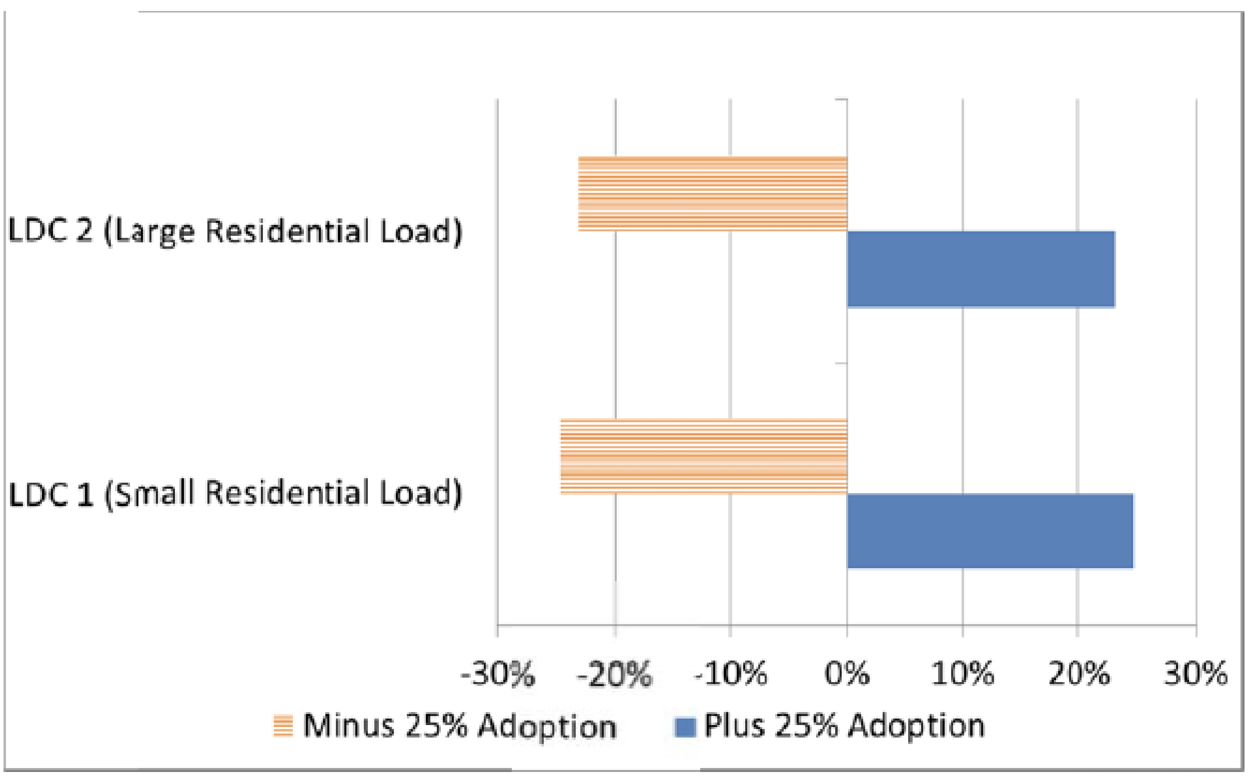
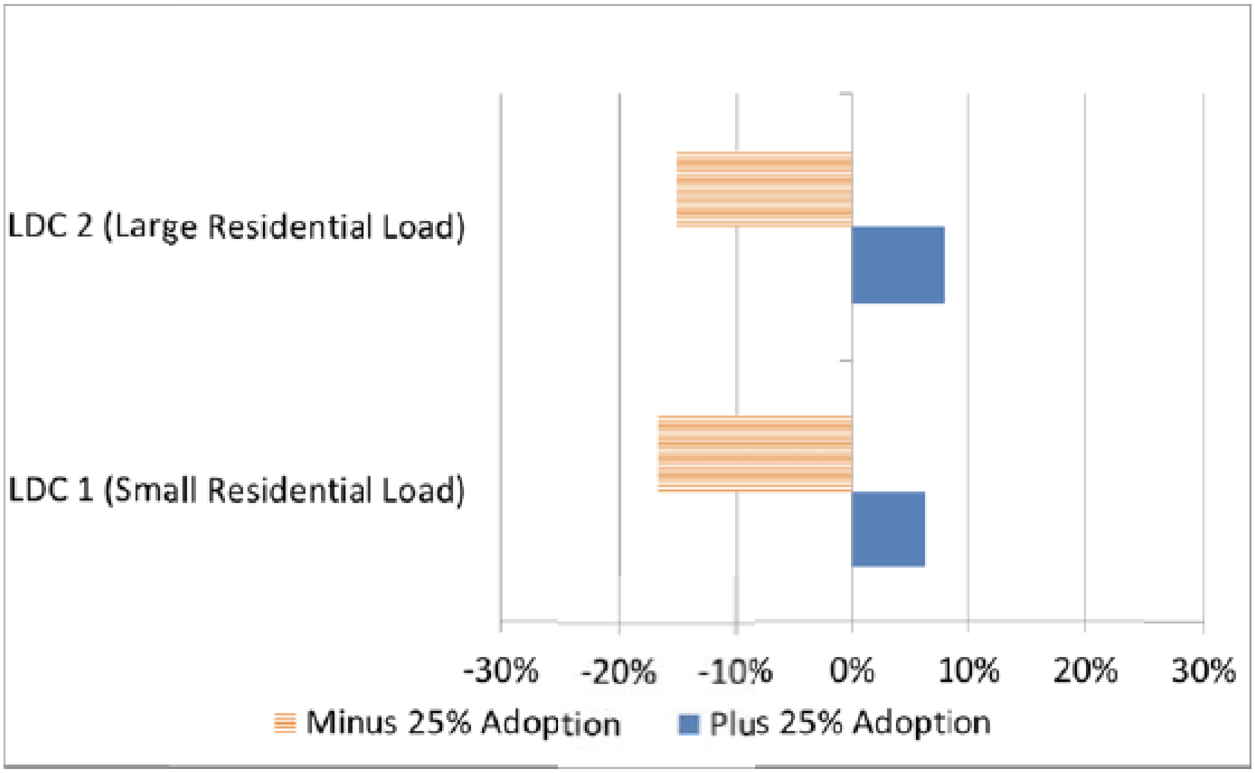


Figure 10-5: Sensitivity to Changes in Adoption Curves – Budget Constrained Achievable



10.2.3 Avoided Cost

The following methodology was used to assess the impact on the achievable potential when avoided costs are changed:

- Avoided costs were revised by +/-25% for the short term horizon.
- The impact on 2020 portfolio energy savings were calculated and were compared with both unconstrained and budget constrained achievable potential base case scenarios.

Figure 10-6 and Figure 10-7 provide the results of the sensitivity analysis and indicate for both unconstrained and budget constrained scenarios. A small correlated impact is observed for the unconstrained potential, where a 25% increase in avoided costs leads to a small amount of additional potential of about 3%. There are only a few measures that get “bumped” over the cost-effectiveness threshold with a 25% increase in avoided cost, and vice-versa for a 25% decrease in avoided costs the potential is slightly reduced. The sensitivity analysis indicates that the residential sector is more sensitive to changes in avoided costs, as shown by LDC 2 being more sensitive to the changing avoided costs compared to LDC 1.

For the budget constrained achievable potential scenario there doesn't seem to be any direct correlation with an increase or decrease of avoided cost. A potential reason for these results is that the change in measures (as measures get added/removed from the program) and the cost to deliver the measures that actually get adopted in each scenario (+/-25%) are not correlated with the avoided costs. That is, even though avoided costs increase by 25% and a few more measures are included in the portfolio, the cost to deliver those added measures (based on acquisition cost) is on average greater, and therefore the budget-cap is reached sooner.

Figure 10-6: Sensitivity to Changes in Avoided Costs – Unconstrained Achievable

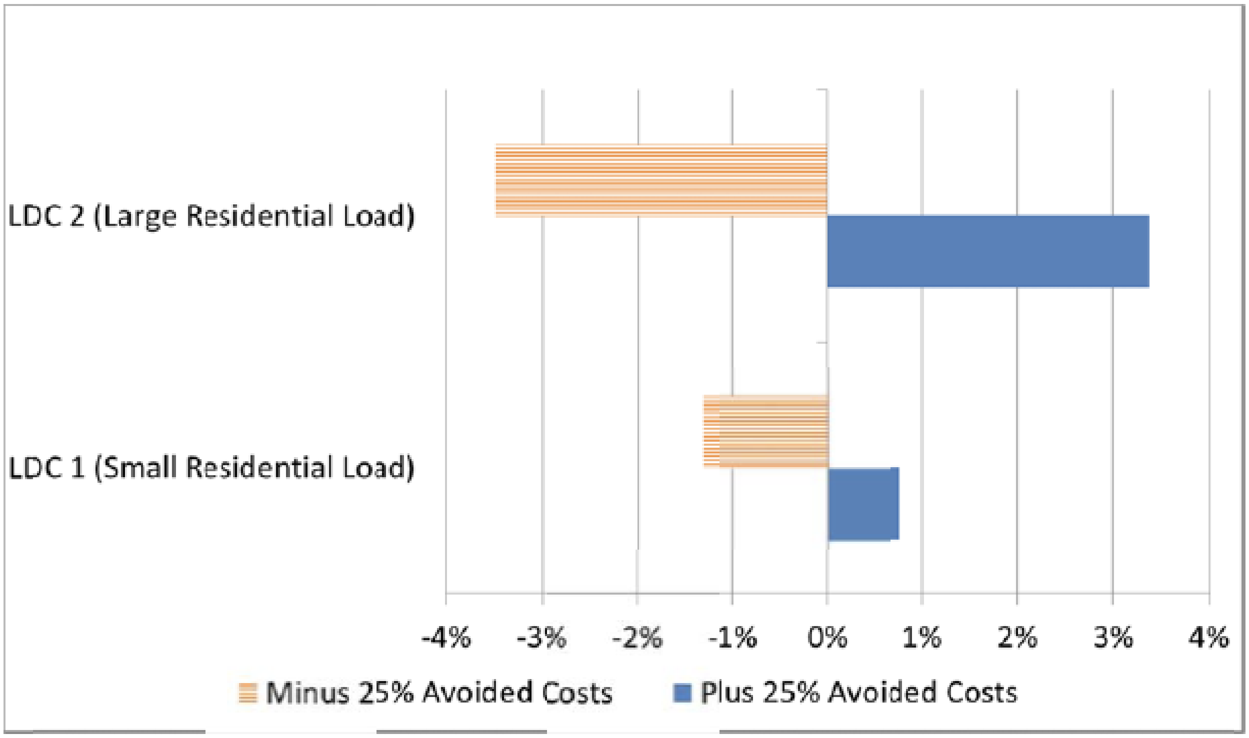
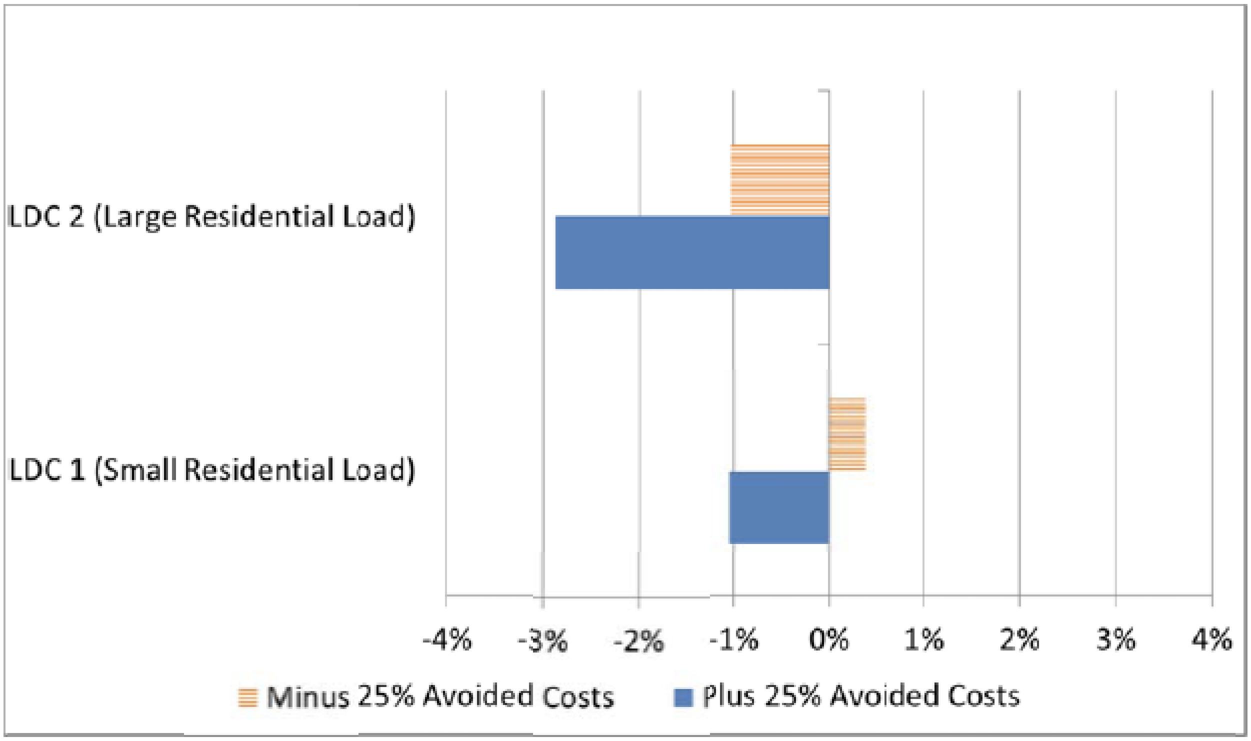


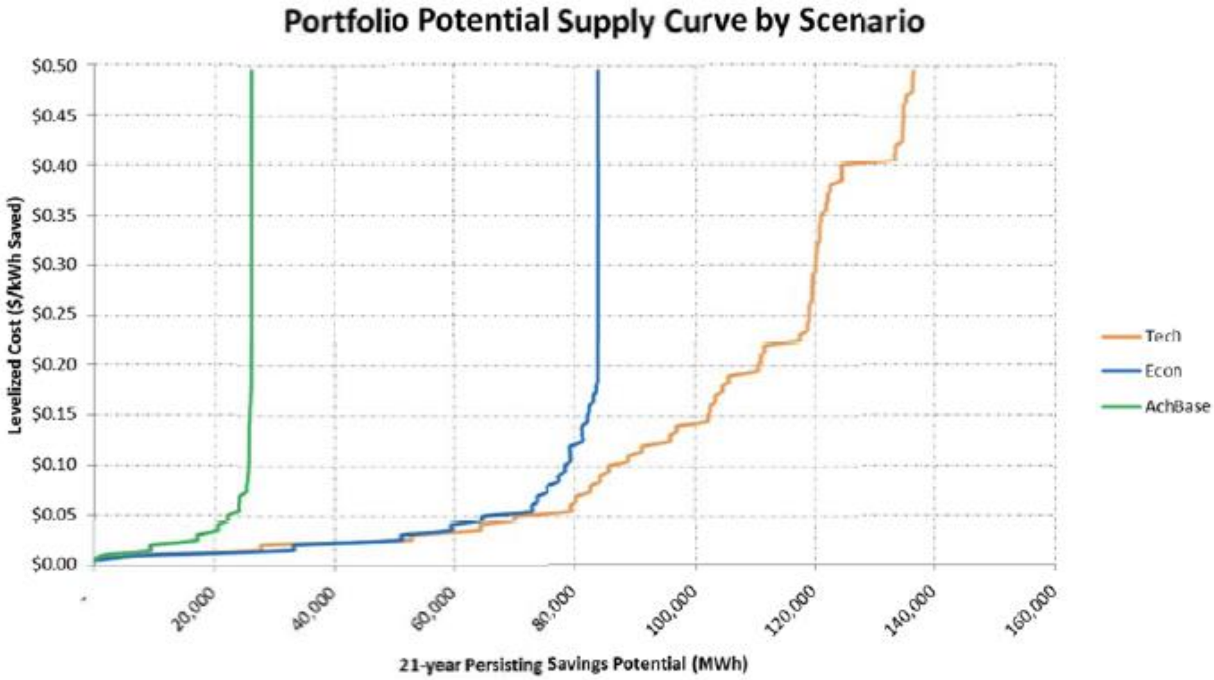
Figure 10-7: Sensitivity to Changes in Avoided Costs – Budget Constrained Achievable



10.3 Cost Curves

Nexant developed distinct cost curves for each scenario (Technical, Economic and Achievable potential), for each sector, and IESO Zone, at each time horizon of the study. Cost curves are a useful tool to visually display the cost of acquiring energy efficiency savings when compared with the cost of other supply side resources (e.g. natural gas power plants). The cost curves were developed using direct outputs from Nexant's TEAPOT model, and then incorporated into a dynamic Microsoft Excel-based cost curve tool. The cost curve tool was provided to IESO as a deliverable of the project. The cost curve tool displays both the total MWh savings by scenario, by sector, by IESO Zone as well as the average levelized cost to obtain those savings. Figure 10-8 below shows a sample figure of the cost to acquire the 21-year portfolio energy savings in the Bruce IESO Zone for each scenario.

Figure 10-8: Example Cost Curve



10.4 Behind-the-Meter Generation (BMG)

The potential for electricity reduction resulting from behind-the-meter generation (BMG) was assessed in a separate study and the methodology and results are presented in a separate report published by IESO. The results from the BMG study were used to determine the total achievable potential for electricity reduction. To ensure no double counting of electricity reduction occurred, the energy efficiency (EE) potential was modelled using a reference case forecast that was reduced by the value of the BMG potential. The total budget constrained EE potential is 17,810 GWh in 2035 as discussed in Section 9. The total budget was derived from an extrapolation of the budget estimate developed for the short term achievable potential analysis. The total constrained budget for EE is $ 5,479 million for 2015 – 2035 and is summarized in Table 10-3.

The total budget constrained achievable potential for EE and BMG is estimated to be 19,390 GWh in 2035 and the budget associated with the achievable potential is $ 5,783 million.

Table 10-3: Provincial Budget Constrained Achievable Potential: Budget and Savings

Option	Spending($ million)	Savings(GWh)
EE	5,479	17,810
BMG	304	1,580
Total APS	**5,783**	**19,390**

11 Conclusions and Recommendations

This section provides a summary of the conclusion from the potential analysis and recommendations on how future achievable potential studies can be improved both through study processes and through additional data collection.

11.1 Conclusion from Potential Analysis

In the 2014 base year, the largest portion of electricity was consumed by the commercial sector (57,279 GWh/year or 43% of the total electricity use), followed by the residential sector (39,461 GWh or 30%) while the industrial sector uses the smallest portion of electricity (36,282 GWh or 27%). The residential single family subsector accounts for the largest electricity use by subsector with 29,974 GWh/year. The end use with the largest electricity use is general interior lighting in the commercial sector with 15,964 GWh/year.

The load forecast for 2015 to 2020 estimates a total increase in electricity use of 11% from 133,022 GWh in 2014 to 147,147 GWh in 2035. The commercial sector is expected to provide the largest increase in electricity use, rising to 10,218 GWh by 2035 (an 18% increase). The growth in electricity se is mainly due to the expected increase in commercial floor space. The residential sector electricity use is expected to decrease by 5%, which is mainly due to the continued conversion of space heating and water heating fuel share, the rising share of multi-residential dwellings and more efficient appliances. The industrial sector is undergoing significant economic restructuring in the short term and the electricity use is expected to increase by 16%. In absolute terms, the largest decrease in electricity consumption by subsector is expected to occur in the residential single family and industrial paper and primary metals manufacturing subsectors. The largest increases in electricity by subsectors are expected to occur in most of the commercial subsectors.

The persistent savings in 2035 range from 53% for the technical potential to 12% for the budget constrained achievable potential when compared to the reference case forecast, as illustrated in Figure 11-1. The budget constrained achievable potential in 2035 is estimated to be an annual persistent saving of 17,810 GWh as summarized in Table 11-2 The largest portion of the savings is from the commercial sector, which accounts for 78% of the budget constrained achievable potential savings. Since the commercial sector accounts for the largest portion of electricity use it is expected to also account for the largest savings potential.

Figure 11-1: Potential Scenarios Compared with Baseline and Reference Case

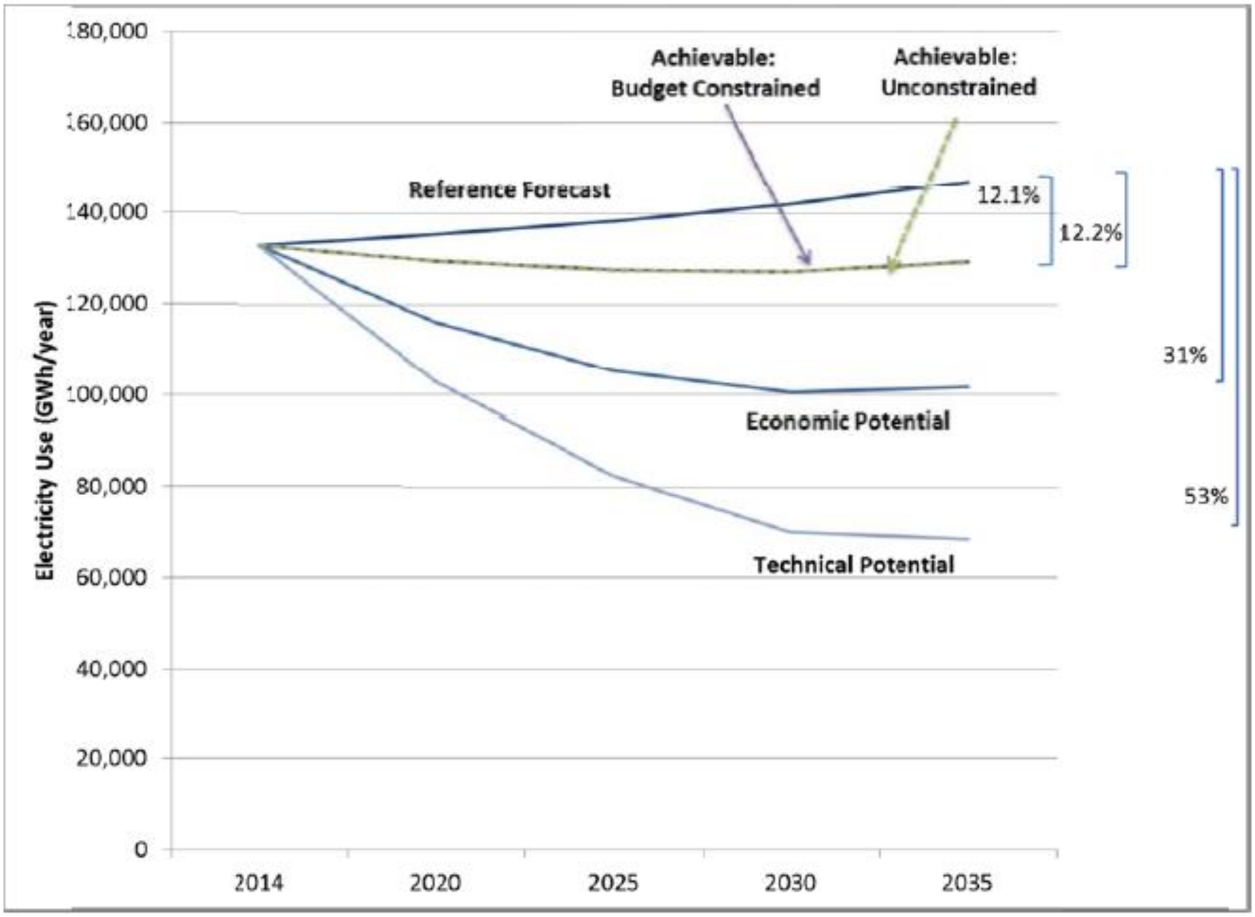


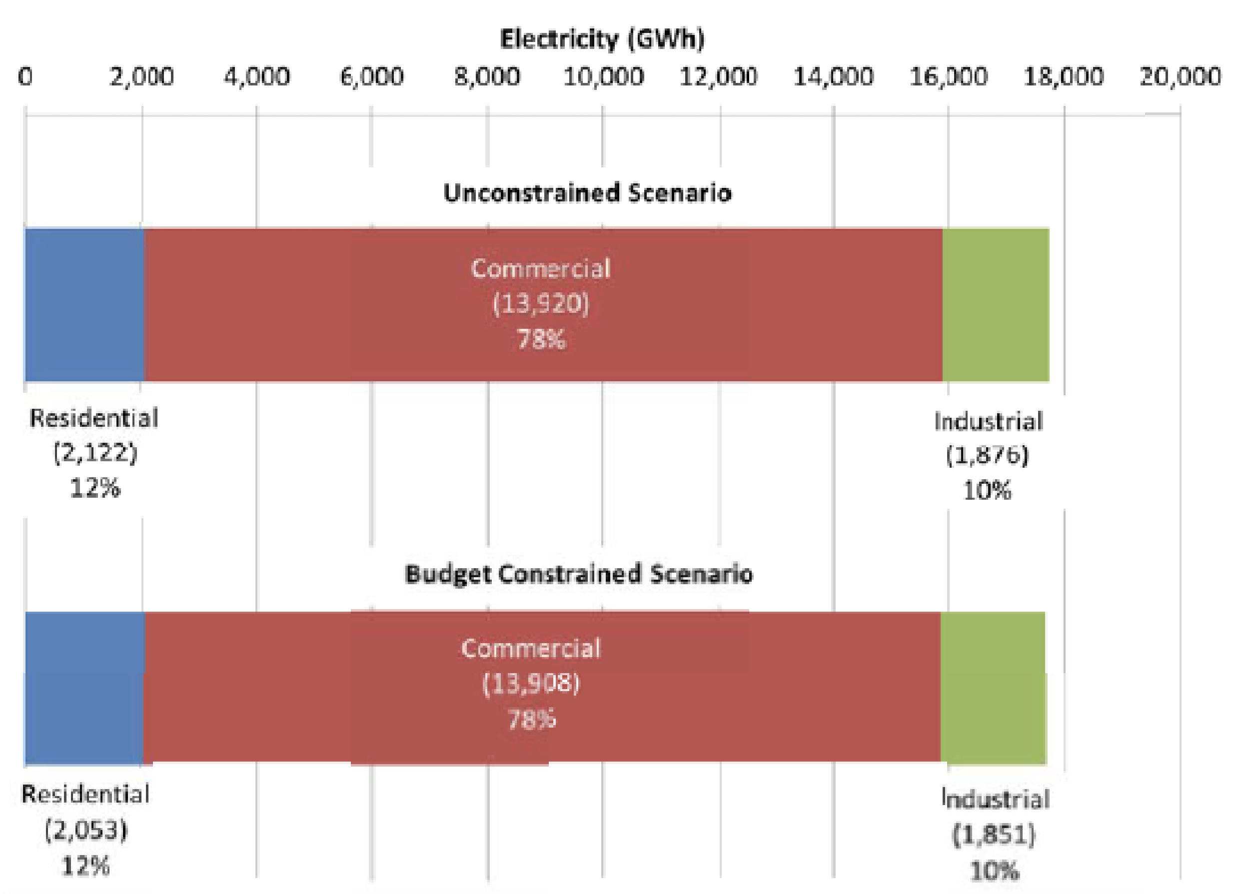
Table 11-1: Annual Electricity Use by Scenario for 2014 to 2035 (GWh/year)

Scenario	2014	2015	2020	2025	2030	2035
Base Year and Reference Case	133,022	130,329	135,562	138,328	142,129	147,147
Achievable Potential: Budget Constrained	133,022	129,708	129,575	127,523	127,282	129,336
Achievable Potential: Unconstrained	133,022	129,696	129,516	127,436	127,181	129,229
Economic Potential	133,022	126,983	116,081	105,338	100,451	101,633
Technical Potential	133,022	124,609	102,816	82,530	70,185	68,565

Table 11-2: Persistent Savings by Scenario in 2035 (GWh/year)

Scenario	2035
Technical Potential	78,581
Economic Potential	45,514
Achievable Potential: Unconstrained	17,918
Achievable Potential: Budget Constrained	17,810

Figure 11-2: Achievable Potential Persistent Savings by Sector in 2035



Comparing the TRC and PAC for the achievable potential scenarios, the commercial and industrial sectors are relatively more cost effective compared to the residential sector. TRC for the commercial sector is 3.6, compared to 1.7 for the residential sector and 2.7 for the industrial sector.

The portfolio acquisition cost is estimated to be $ 308 / MWh for the budget constrained scenario. In the budget constrained scenario the commercial sector has the lowest acquisition cost at $ 208 / MWH and the residential sector the highest cost at $ 961 / MWh.

The budget constrained scenario indicates that the portion of residential load affects the impact of increasing or decreasing the incentive rates. Due to the lower price elasticity for the residential sector, for an LDC with a relatively larger portion residential load the more money that is allocated to incentives does not result in incrementally more savings.

For both unconstrained and budget constrained scenarios the increase or decrease in savings are relatively proportional to the changes in adoption rates. Increased adoption rates in the budget constrained scenario do have a sign ficantly lower impact on increased savings compared to the unconstrained scenario. A 25% increase in adoption rates result in an increase savings of between 6% and 8% in the budget constrained achievable potential scenario, compared to 23% to 24% for the unconstrained achievable potential scenario.

A small correlated impact is observed for the unconstrained potential, where a 25% increase in avoided costs leads to a small amount of additional potential of about 3%. The sensitivity analysis indicates that the residential sector is more sensitive to changes in avoided costs. For the budget constrained achievable potential scenario there doesn't seem to be any direct correlation with an increase or decrease of avoided cost. A potential reason for this result is that the change in measures (as measures get added/removed from the program) and the cost to deliver the measures that actually get adopted in each scenario (+/-25%) is not correlated with the avoided costs.

The total budget constrained achievable potential for EE and BMG is 19,390 GWh in 2035 and the budget associated with the achievable potential is $ 6,061 million.

11.2 Recommendations for Future Studies

Since the long term analysis was built from the bottom up, using the short term analysis as a foundation, the recommendations are aligned with the short term analysis. With input from IESO and the Working Group, recommendations were identified to improve data, accuracy, address gaps an enhance the process for future potential analyses. The full list of recommendations is provided in the report for the short term analysis and only the items of specific relevance to the long term analysis are repeated here:

Overall Process, Methodology and Schedule

- Sufficient time needs to be allocated to generate and review draft results. It is recommended to conduct test model runs and to review draft results prior to undertaking a full model run, since a full model run requires significantly more time and effort compared to a test model run.
- Methodologies and approaches were reviewed and adjusted as needed throughout the study. In some cases extra time would have provided even more opportunity to refine the methodologies. In future studies it may be beneficial to identify key methodologies and plan extra time for review of these methodologies and their implications.
- The study used an optimized TRC ranking approach to estimate the budget constrained achievable potential. Depending on the objectives of future potential studies it may be beneficial to review additional approaches to develop budget constrained achievable potential.

- This was the first time that both EE and BMG potential was assessed and integrated to derive the potential savings. Combining the two studies into one study will assist in a more effective alignment of the methodologies and schedule of the integration.
- The study was completed in mid-2016 and used 2014 as the base year, but close to the completion of the project, program evaluation data became available for 2015. It is recommended to consider the timing of the program evaluation results when scheduling the achievable potential study and when selecting the base year.

Data Collection:

- Since the study followed a bottom-up approach that was LDC and program focused, it is important to obtain as much LDC and program primary data as possible.
- Obtaining LDC data prior to the formal kick-off of the study assisted in optimizing the time required to conduct the study.
- Program performance data provides important input for the study, especially in terms of understanding participation rates and measure take up. Accurately tracking this information and being able to access the information for the study, will help to increase the accuracy of future studies. This is especially applicable to the commercial programs and measures, since the largest potential is identified in this sector but the tracking of measure take up and participation in programs occur at a very aggregated level. It is recommended that IESO identify internal program data at the measure level that can be leveraged for future potential studies.

Measures:

- The incentive rate is a significant driver in the acquisition costs (typically representing the majority of the program delivery costs). The incentive rates were provided to Nexant by IESO (based on 2014 evaluation findings). While fairly good records are kept on the incentive costs, information on the average measure incremental costs was not as well organized. A provincial-wide database that tracks measure incremental costs would be useful for the accurate estimation of incentive rates.
- The IESO's M&A list and measure database are important information sources for the achievable potential studies. It is recommended to expand the measure database to include:
    a) Baseline information about residential and commercial average equipment efficiencies (e.g. average Central AC SEER value) and building characteristics (e.g. average residential ceiling R-value) throughout the province.
    b) Province-wide measure incremental cost data.
    c) 8760 avoided energy costs (currently the avoided energy costs are seasonal).
    d) Assign climate zone specific deemed savings and costs for key parameters, such as: lighting hours o use (HOU) and HVAC EFLH

Coordination with Natural Gas DSM Programs

- A few measures are applicable to both CDM and DSM programs. It is recommended to share data relevant to the take up of these measures to inform future potential studies.
- The shared data can also assist in program design and program delivery to minimize duplication of efforts between LDCs and the gas utilities.

12 Acronyms

ACP: Aboriginal Conservation Program

BC: Benefit/Cost

CAC: Central air conditioning

CDM: Conservation and demand management

CEE: Consortium for Energy Efficiency

CFL: Compact fluorescent light bulb

C&I: Commercial and industrial

DX: Direct expansion

EE: Energy effici ncy

ECM: Electronically commutated motor

EFLH: Equivalent full load hours

HOU: Hours of Use

HPNC: High performance new construction

HVAC: Heating, ventilation and air conditioning

HVLS: High-volume low-speed

IESO: Independent Electricity System Operator

LDC: Local distribution company

LED: Light-emitting diode

NAICS: North American Industry Classification System

OEB: Ontario Energy Board

PAC: Program administrative cost test

SBL: Small Business Lighting

TCU: Transportation, communication and utilities facilities

TRC: Total resource cost

Appendix A: Subsector Definitions

The table provides definition descriptions for each of the subsectors used in the study.

Residential Sector

Subsector	Description
Single Family Row House	Single-family, detached households Single-family, attached households (e.g. townhomes)
Multi-Residential Low Rise Multi-Residential High Rise Other Residential	Individually/suite-metered units in multi-unit residential buildings (MURB) less than 5 stories Individually/suite-metered units in multi-unit residential buildings (MURB) greater than or equal to 5 stories. Miscellaneous residential households not included in single family, row house or multi-residential (e.g. mobile homes)

Commercial Sector

Subsector	Description
Large Office	Office buildings greater than 20,000 square feet including government offices
Small Office Non Food Retail	Office buildings less than or equal to 20,000 square feet including government offices
Large Office	All retail buildings whose primary business operation does not include the sale of food (e.g. department stores, car dealerships, hardware stores, etc.)
Food Retail	Retail buildings whose primary business operation includes the sale of food (e.g. supermarkets, beverage stores, convenience stores, etc.)
Restaurant	Full service restaurants, caterers, cafeterias, and pubs Hotel and motel overnight accommodation buildings
Lodging	Inpatient and outpatient health facilities, as well as buildings whose primary business operations include healthcare related services (e.g. labs and dialysis centers)
Hospitals	Home healthcare facilities and homes for the elderly
Nursing Home	Elementary and secondary education, apprenticeship, training, and daycares facilities

Subsector	Description
Schools	Post-secondary education facilities including community colleges Warehouse and wholesale distribution facilities
Universities	Buildings whose primary purpose is to house computer servers Transportation, communication and utilities facilities
Warehouse Facilities	Office buildings greater than 20,000 square feet including government offices
Data Center	Office buildings less than or equal to 20,000 square feet including government offices
TCU	All retail buildings whose primary business operation does not include the sale of food (e.g. department stores, car dealerships, hardware stores, etc.)
Multi-unit residential	All multi-unit residential building (MURB) units that are bulk metered, including co mon area energy load from both individually and bulk metered MURBs
Other Commercial Buildings	All other commercial building types not specified above (e.g. theaters, sports arenas, libraries, bowling alleys, auto repair, amusement parks, etc.)

Industrial Sector

Subsector	Description
Primary Metals	Facilities, mills and foundries that manufacture products from primary metals (e.g. iron & steel mills, aluminum manufacturers, iron foundries, etc.)
Non-Metallic Minerals	Manufacturing of non-metallic minerals including brick, clay, ceramics, glass and concrete products
Chemical Manufacturing	Manufacturing of chemicals from petroleum and coal products
Petroleum Refineries	Facilities whose primary operations is the refining of petroleum products
Plastic and Rubber Manufacturing	Plastic material and resin manufacturing, synthetic rubber manufacturing, and all other facilities involved in the manufacture of plastic and rubber products
Paper Manufacturing	Paper, pulp and paper-product mills and associated manufacturing

Subsector	Description
Food and Beverage Manufacturing	Manufacturing of food and beverage products (e.g. mills, cheese manufacturing, breweries, distilleries, commercial bakeries, etc.)
Auto Parts Manufacturing	Automotive and automotive parts manufacturing, as well as other transportation equipment manufacturing (e.g. aircraft engines)
Fabricated Metals	Fabricated metal product manufacturing (e.g. sheet metal, iron & steel forging, metal stamping, etc.)
Electronic Manufacturing	Computer and electronic device and parts manufacturing
Wood Products Manufacturing	Sawmills, veneer and plywood manufacturing and other wood product manufacturing facilities
Mining	Mining facilities and associated load (e.g. oil and gas extraction, ore mining, quarries, etc.)
Agricultural	Agricultural facilities and operations for farming, vineyards, greenhouses, etc.
Miscellaneous Industrial	All other industrial facilities not specified above (e.g. construction, textile manufacturing, apparel, machinery, furniture, toy manufacturing, printing, etc.)

Appendix B: Mapping of EE Measures to Archetype Programs

The following tables provide the mapping of measures to archetype programs (see report for short term analysis for discussion on archetype programs) and adoption curves for the residential, commercial and industrial sectors.

Residential Sector

Measure	Program	Adoption Curve
ENERGY STAR Dryers	Consumer Program	AchNew_Misc appliance
Clothes Washers CEE Tier 1/ ENERGY STAR	Consumer Program	AchNew_Misc appliance
Clothes Washers CEE Tier 2	Consumer Program	AchNew_Misc appliance
Clothes Washers CEE Tier 3	Consumer Program	AchNew_Misc appliance
ENERGY STAR® DEHUMIDIFIER	Consumer Program	AchExisting_dehumidifier
ENERGY STAR Dishwashers (Electric Water Heating)	Consumer Program	AchNew_Misc appliance
ENERGY STAR Dishwashers (Gas Heating)	Consumer Program	AchNew_Misc appliance
Heat Pump Water Heaters 50 gallon	Systems and equipment program	AchNew_Misc all
Solar Water Heaters	Systems and equipment program	AchNew_Misc all
Heat Pump Water Heaters 80 gallon	Systems and equipment program	AchNew_Misc all
Instantaneous Water Heater	Systems and equipment program	AchNew_Misc appliance
ENERGY STAR Freezer	Consumer Program	AchExisting_freezer
CEE Tier 2 Freezer	Consumer Program	AchExisting_freezer
CEE Tier 3 Freezer	Consumer Program	AchExisting_freezer
Freezer Recycling with Replacement	Consumer Program	AchExisting_freezer
Freezer Recycling without Replacement	Consumer Program	AchExisting_freezer
ENERGY STAR® QUALIFIED LED BULBS - Specialty LEDs (Flood/Reflector)	Consumer Program	AchExisting_led
ENERGY STAR® QUALIFIED LED BULBS - Specialty LEDs (Globe)	Consumer Program	AchExisting_led
ENERGY STAR® QUALIFIED LED BULBS - Specialty LEDs (Candle)	Consumer Program	AchExisting_led
ENERGY STAR® QUALIFIED SPECIALTY COMPACT FLUORESCENT LAMPS (CFLS) - 19W Dimmable CFL	Consumer Program	AchExisting_cfl
ENERGY STAR® QUALIFIED SPECIALTY COMPACT FLUORESCENT LAMPS (CFLS) - Chandelier CFLs	Consumer Program	AchExisting_cfl
ENERGY STAR® QUALIFIED COMPACT FLUORESCENT LAMPS (CFLS)-COVERED CFL	Consumer Program	AchExisting_cfl

Measure	Program	Adoption Curve
ENERGY STAR® QUALIFIED SPECIALTY COMPACT FLUORESCENT LAMPS (CFLS) - Globe CFLs	Consumer Program	AchExisting_cfl
ENERGY STAR® QUALIFIED SPECIALTY COMPACT FLUORESCENT LAMPS (CFLS) - 26W, Indoor	Consumer Program	AchExisting_cfl
ENERGY STAR® QUALIFIED SPECIALTY COMPACT FLUORESCENT LAMPS (CFLS) - 26W, Outdoor	Consumer Program	AchExisting_cfl
ENERGY STAR® QUALIFIED SPECIALTY COMPACT FLUORESCENT LAMPS (CFLS) - High Wattage 3-Way CFL	Consumer Program	AchExisting_cfl
ENERGY STAR® QUALIFIED SPECIALTY COMPACT FLUORESCENT LAMPS (CFLS) - Low Wattage 3-Way CFL	Consumer Program	AchExisting_cfl
ENERGY STAR® QUALIFIED COMPACT FLUORESCENT LAMPS (CFLS) TRI-LIGHT	Consumer Program	AchExisting_cfl
ENERGY STAR® QUALIFIED COMPACT FLUORESCENT LAMPS (CFLS) TWISTER - 13 W CFL Twister	Consumer Program	AchExisting_cfl
ENERGY STAR QUALIFIED LIGHT FIXTURE - 1 OR 2 SOCKETS (CFL)	Consumer Program	AchExisting_cfl
ENERGY STAR QUALIFIED LIGHT FIXTURE - 3 OR MORE SOCKETS (CFL)	Consumer Program	AchExisting_cfl
ENERGY STAR QUALIFIED RECESSED LIGHTING-LED	Consumer Program	AchExisting_led
ENERGY STAR QUALIFIED RECESSED LIGHTING-CFL	Consumer Program	AchExisting_cfl
ENERGY STAR QUALIFIED UNDER THE COUNTER LIGHTING - LED	Consumer Program	AchExisting_led
LED Nightlight	Consumer Program	AchExisting_led
Electroluminescent Nightlight	Consumer Program	AchExisting_led
Energy Star Torchiere	Consumer Program	AchExisting_led
Holiday Lights	Consumer Program	AchExisting_led
ENERGY STAR LED 5W	Consumer Program	AchExisting_led
ENERGY STAR LED 7W	Consumer Program	AchExisting_led
ENERGY STAR LEDL 12W	Consumer Program	AchExisting_led
ENERGY STAR LED 18W	Consumer Program	AchExisting_led
ENERGY STAR LED 25W	Consumer Program	AchExisting_led
ENERGY STAR CFL 10W	Consumer Program	AchExisting_cfl
ENERGY STAR CFL 15W	Consumer Program	AchExisting_cfl
ENERGY STAR CFL 25W	Consumer Program	AchExisting_cfl
ENERGY STAR CFL 40W	Consumer Program	AchExisting_cfl
ENERGY STAR CFL 20W	Consumer Program	AchExisting_cfl
High Efficiency Bathroom Exhaust Fan	Consumer Program	AchNew_fans
Variable Speed Pool Pump Motors	Consumer Program	AchNew_timer
Dual Speed Pool Pump Motors	Consumer Program	AchNew_timer

Measure	Program	Adoption Curve
ENERGY STAR Printer	Consumer Program	AchNew_Misc appliance
ENERGY STAR Water Coolers	Consumer Program	AchNew_Misc appliance
ENERGY STAR Air Purifier/Cleaner	Consumer Program	AchNew_Misc appliance
ENERGY STAR TV	Consumer Program	AchNew_Misc appliance
ENERGY STAR Qualified Audio/Video Equipment - Audio Amplifiers	Consumer Program	AchNew_Misc appliance
ENERGY STAR Qualified Audio/Video Equipment - Optical Disc Player	Consumer Program	AchNew_Misc appliance
ENERGY STAR Qualified Computers - Desktop	Consumer Program	AchNew_Misc appliance
ENERGY STAR Qualified Computers- Notebook	Consumer Program	AchNew_Misc appliance
ENERGY STAR Qualified Displayes (Monitors)	Consumer Program	AchNew_Misc appliance
ENERGY STAR Qualified Game Consoles	Consumer Program	AchNew_Misc appliance
ENERGY STAR Qualified Set Top Box	Consumer Program	AchNew_Misc appliance
ENERGY STAR Refrigerator	Consumer Program	AchExisting_refrigerator
CEE Tier 2 Refrigerator	Consumer Program	AchExisting_refrigerator
CEE Tier 3 Refrigerator	Consumer Program	AchExisting_refrigerator
Refrigerator Recycling with Replacement	Consumer Program	AchExisting_refrigerator
Refrigerator Recycling without Replacement	Consumer Program	AchExisting_refrigerator
ENERGY STAR Ceiling Fans	Consumer Program	AchExisting_fans
ENERGY STAR® Room Air Conditioner	Consumer Program	AchExisting_air conditioner
ENERGY STAR® Central Air Conditioner 14.5 SEER	Systems and equipment program	AchExisting_CACI
ENERGY STAR® Central Air Conditioner 16 SEER	Systems and equipment program	AchExisting_CACII
ENERGY STAR® Central Air Conditioner 15 SEER	Systems and equipment program	AchExisting_CACI
ENERGY STAR® Central Air Conditioner 18 SEER	Systems and equipment program	AchExisting_CACII
ENERGY STAR® Central Air Conditioner 20 SEER	Systems and equipment program	AchExisting_CACII
ENERGY STAR® Room Air Conditioner (8000-9999 Btuh)	Consumer Program	AchExisting_air conditioner
Residential Whole House Fan	Systems and equipment program	AchExisting_fans
Ductless Mini Split Air Conditioner 16 SEER	Systems and equipment program	AchExisting_air conditioner
Installing ECM on an Electric Furnace (Non-continuous Usage)	Systems and equipment program	AchExisting_ECM
Installing ECM on an Gas Furnace (Non-continuous Usage)	Systems and equipment program	AchExisting_ECM
Ductless Mini Split Heat Pump 16 SEER	Systems and equipment program	AchExisting_refrigerator
Air Source Heat Pump 15 SEER 8.5 HSPF	Systems and equipment program	AchNew_ECMII

Measure	Program	Adoption Curve
Air Source Heat Pump 16 SEER 9 HSPF	Systems and equipment program	AchNew_ECMII
Ground Source Heat Pump 17 EER 3.6 COP	Systems and equipment program	AchNew_ECMII
Ground Source Heat Pump 17 SEER 3.6 COP	Systems and equipment program	AchNew_ECMII
Ground Source Heat Pump 17 EER / 3.6 COP - with desuperheater	Systems and equipment program	AchNew_ECMII
Residential New Construction Tier 1 (10% more efficient)	Systems and equipment program	AchExisting_Misc all
Residential New Construction Tier 2 (20% more efficient)	Systems and equipment program	AchExisting_Misc all
Residential New Construction Tier 3 (30% more efficient)	Systems and equipment program	AchExisting_Misc all
Home Energy Reports	Behaviorual	Ach_HER
CLOTHESLINES	Consumer Program	AchExisting_air dry
WATER HEATER BLANKET	Consumer Program	AchExisting_dhw blanket
EFFICIENT AERATORS - Kitchen - Flow Rate < 5.7 L/min	Consumer Program	AchExisting_pipes
EFFICIENT AERATORS - Bathroom - Flow Rate < 3.8 L/min	Consumer Program	AchExisting_pipes
EFFICIENT SHOWERHEAD (HANDHELD) 2.8 L/min	Consumer Program	AchExisting_pipes
EFFICIENT SHOWERHEAD (HANDHELD) 3.8 L/min	Consumer Program	AchExisting_pipes
EFFICIENT SHOWERHEAD (STANDARD) 3.8 L/min	Consumer Program	AchExisting_pipes
EFFICIENT SHOWERHEAD (STANDARD) 2.8 L/min	Consumer Program	AchExisting_pipes
HOT WATER PIPE WRAP - Per 3' Pipe Wrap (3/4" Pipe)	Audit and direct install	AchExisting_pipes
Water Heater Temperature Setback	Audit and direct install	AchExisting_pipes
Thermostatic Shower Restriction Valve	Systems and equipment program	AchNew_Misc all
Drain Water Heat Recovery Device	Systems and equipment program	AchNew_Misc all
Furnace Whistle	Audit and direct install	AchExisting_pipes
LIGHTING TIMERS (HARD-WIRED, INDOOR)	Consumer Program	AchExisting_timer
Motion Sensors (Hard-wired, Indoor)	Consumer Program	AchExisting_light control
Dimmer Switch (Hard-wired)	Consumer Program	AchExisting_light control
Outdoor Lighting Timer	Consumer Program	AchExisting_timer
Outdoor Motion Sensor	Consumer Program	AchExisting_light control
Heavy Duty Plug-in Timers - Spa Pump Timer	Consumer Program	AchExisting_timer
Heavy Duty Plug-in Timers - Pool Pump Timer	Consumer Program	AchExisting_timer
Heavy Duty Plug-in Timers - Car Block Timer	Consumer Program	AchExisting_timer
Smart Strip Plug Outlets- Home Office connected to Television	Consumer Program	AchExisting_powerbar
Smart Strip Plug Outlets- Home Office	Consumer Program	AchExisting_powerbar

Measure	Program	Adoption Curve
Smart Strip Plug Outlets - Entertainment Center	Consumer Program	AchExisting_powerbar
Central AC Maintenance/Tune Up	Whole-home Program	AchExisting_Misc all
Programmable Thermostat- Baseboard Heating	Consumer Program	AchExisting_thermo
Programmable Thermostat- Electric Forced Air Heating	Consumer Program	AchExisting_thermo
Smart Thermostat	Consumer Program	AchExisting_thermo
Heat Pump Maintenance/Tune Up	Whole-home Program	AchNew_Misc all
Ceiling Insulation going from R-20 to R-60	Whole-home Program	AchExisting_shell
Ceiling Insulation going from R-5 to R-60	Whole-home Program	AchExisting_shell
Ceiling Insulation going from R-5 to R-49	Whole-home Program	AchExisting_shell
Ceiling Insulation going from R-30 to R-49	Whole-home Program	AchExisting_shell
Ceiling Insulation going from R-20 to R-49	Whole-home Program	AchExisting_shell
Ceiling Insulation going from R-30 to R-60	Whole-home Program	AchExisting_shell
Wall Insulation going from R-4 to R-23	Whole-home Program	AchExisting_shell
Wall Insulation going from R-4 to R-29	Whole-home Program	AchExisting_shell
Wall Insulation from R-4 to R-13	Whole-home Program	AchExisting_shell
Wall Insulation from R-4 to R-19	Whole-home Program	AchExisting_shell
Floor Insulation from R5 to R 30	Whole-home Program	AchExisting_shell
Floor Insulation going from R-5 to R 38	Whole-home Program	AchExisting_shell
Basement Wall Insulation going from R-3 to R-15	Whole-home Program	AchExisting_shell
Basement Wall Insulation going from R-3 to R-10	Whole-home Program	AchExisting_shell
Air Sealing 13 to 9 ACH50	Whole-home Program	AchExisting_shell
Air Sealing 9 to 7 ACH50	Whole-home Program	AchExisting_shell
Duct Sealing from 38.5% to 25%	Whole-home Program	AchNew_shell
Duct Sealing from 25% to 16.25%	Whole-home Program	AchNew_shell
Duct Insulation from R-0 to R-8	Whole-home Program	AchNew_shell
Window Film (U=0.51, SHGC=0.24)	Whole-home Program	AchNew_shell
ENERGY STAR Windows (U=0.25, SHGC=0.40)	Whole-home Program	AchNew_shell
ENERGY STAR Windows (U=0.30, SHGC=0.40)	Whole-home Program	AchNew_shell
ENERGY STAR Windows (U=0.35, SHGC=0.40)	Whole-home Program	AchNew_shell
Radiant Barrier	Whole-home Program	AchNew_shell
Drain Water Heat Recovery	Systems and equipment program	AchNew_Misc all
Low Income Program	Low Income Program	AchExisting_Misc all
Aboriginal Program	Aboriginal Program	AchExisting_Misc all
Residential New Construction Program	Residential New Construction Program	AchExisting_Misc all

Commercial Sector

Measure	Program	Adoption Curve
ENERGY STAR Scanner	Retrofit Program	Prescriptive_Existing
ENERGY STAR Copiers	Retrofit Program	Prescriptive_Existing
ENERGY STAR® desktop	Retrofit Program	Prescriptive_Existing
ENERGY STAR Fax	Retrofit Program	Prescriptive_Existing
ENERGY STAR Monitors	Retrofit Program	Prescriptive_Existing
ENERGY STAR Printers	Retrofit Program	Prescriptive_Existing
Smart Strip Plug Outlets	Small Business Program	Engineered_Existing
Electrically Commutated Plug fans in data centers	Retrofit Program	Custom_Existing
High Efficiency Hot Food Holding Cabinet	Retrofit Program	Custom_Existing
Efficient Steamer (ENERGY STAR)	Retrofit Program	Custom_Existing
ENERGY STAR Combination Oven	Retrofit Program	Custom_Existing
ENERGY STAR Convection Oven	Retrofit Program	Custom_Existing
High Efficiency Fryer (ENERGY STAR)	Retrofit Program	Custom_Existing
High Efficiency Griddle (ENERGY STAR)	Retrofit Program	Custom_Existing
High Efficiency Induction Cooking	Retrofit Program	Custom_Existing
High Efficiency Air Cooled Chiller, 100 Tons	Retrofit Program	Engineered_Existing
High Efficiency Air Cooled Chiller, 150 Tons	Retrofit Program	Engineered_Existing
High Efficiency Water Cooled Centrifugal Chiller, 175 Tons	Retrofit Program	Engineered_Existing
High Efficiency Water Cooled Centrifugal Chiller, 300 Tons	Retrofit Program	Engineered_Existing
High Efficiency Water Cooled Centrifugal Chiller, 500 Tons	Retrofit Program	Engineered_Existing
High Efficiency Water Cooled Centrifugal Chiller, 600 Tons	Retrofit Program	Engineered_Existing
High Efficiency Water Cooled Reciprocating Chiller, 175 Tons	Retrofit Program	Engineered_Existing
High Efficiency Water Cooled Reciprocating Chiller, 300 Tons	Retrofit Program	Engineered_Existing
High Efficiency Water Cooled Reciprocating Chiller, 50 Tons	Retrofit Program	Engineered_Existing
VFD on Cooling Tower Fan	Retrofit Program	Custom_Existing
UNITARY AIR-CONDITIONING UNIT - Split system < 5.4 tons, Electric Resistance, 12.5 EER (per ton)	Retrofit Program	Engineered_Existing
UNITARY AIR-CONDITIONING UNIT - Split system < 5.4 tons, All Other, 12.5 EER (per ton)	Retrofit Program	Engineered_Existing
UNITARY AIR-CONDITIONING UNIT - Single package, ≥ 5.4 to ≤ 7.5 tons, Electric Resistance, 12.2 EER (per ton)	Retrofit Program	Engineered_Existing
UNITARY AIR-CONDITIONING UNIT - Single package, ≥ 7.5 to ≤ 20 tons, Electric Resistance, 11 EER (per ton)	Retrofit Program	Engineered_Existing
UNITARY AIR-CONDITIONING UNIT - Single package < 5.4 tons, All Other, 12.0 EER (per ton)	Retrofit Program	Engineered_Existing
UNITARY AIR-CONDITIONING UNIT - Split system/Single package ≥ 20 to < 63 tons, Electric Resistance, 10.8 EER (per ton)	Retrofit Program	Engineered_Existing
UNITARY AIR-CONDITIONING UNIT - Split system/Single package ≥ 20 to < 63 tons, All Other, 10.6 EER (per ton)	Retrofit Program	Engineered_Existing

Measure	Program	Adoption Curve
UNITARY AIR-CONDITIONING UNIT WITH ECONOMIZER - Single package, ≥ 5.4 to ≤ 7.5 tons, Electric Resistance, 12.2 EER (per ton)	Retrofit Program	Engineered_Existing
ECM Motors for split systems	Retrofit Program	Engineered_Existing
PTAC (12 EER/10,000 BTU)	Retrofit Program	Engineered_Existing
Room AC (w/ louvered sides) 13 SEER from 12 SEER code	Retrofit Program	Prescriptive_Existing
Room AC (w/ louvered sides) 12.5 SEER from 12 SEER code	Retrofit Program	Prescriptive_Existing
Room AC (w/ louvered sides) 14 SEER from 12 SEER code	Retrofit Program	Prescriptive_Existing
Outdoor Air Economizer	Retrofit Program	Engineered_Existing
Ductless Heat Pump	Retrofit Program	Engineered_Existing
Ground Source Heat Pump (Closed Loop)	Retrofit Program	Engineered_Existing
Ground Source Heat Pump (Open Loop)	Retrofit Program	Engineered_Existing
High Efficiency Air Source Heat Pump (12 EER, 3.6 COP)	Retrofit Program	Engineered_Existing
High Efficiency Air Source Heat Pump (12 EER, 2.6 COP)	Retrofit Program	Engineered_Existing
Variable Refrigerant Flow Heat Pump	Retrofit Program	Engineered_Existing
Water Source Heat Pump (4 ton)	Retrofit Program	Engineered_Existing
Heat Pump Water Heater (50 Gallon)	Retrofit Program	Engineered_Existing
High Efficiency Electric Water Heater (50 Gallon)	Retrofit Program	Engineered_Existing
High Efficiency Small Instantaneous Water Heater (30% above the minimum)	Retrofit Program	Custom_Existing
Solar Electric Water Heater (50 Gallon)	Retrofit Program	Custom_Existing
VFD on Hot Water Pump	Retrofit Program	Engineered_Existing
Ozone Generator on Laundry Systems	Retrofit Program	Custom_Existing
Efficient Unit Heating System	Retrofit Program	Custom_Existing
ECM MOTORS FOR HVAC APPLICATION (FAN POWERED VAV BOX)	Retrofit Program	Engineered_Existing
ECM MOTORS FOR HVAC APPLICATION (FAN MOTOR REPLACEMENT	Retrofit Program	Engineered_Existing
Demand Controlled Ventilation	Retrofit Program	Custom_Existing
Variable Speed Drive on Kitchen Exhaust Fan	Retrofit Program	Custom_Existing
VFD on Chilled Water Pump	Retrofit Program	Engineered_Existing
VFD on Condenser Water Pump	Retrofit Program	Engineered_Existing
VFD on HVAC Fan	Retrofit Program	Engineered_Existing
LED EXTERIROR AREA LIGHTS- LED FIXTURE (200W)	Retrofit Program	Prescriptive_Existing
Incandescent to HID (Outdoor)	Retrofit Program	Prescriptive_Existing
Refrigerated Display Case LED Strip Light	Retrofit Program	Engineered_Existing
T8 Lamps & Electronic Ballast	Small Business Program	SBL LED_Existing
Energy Star LED lamps- Omnidirectional A shape or Wet Location Rates Par 10W	Small Business Program	SBL LED_Existing
LED Recessed Downlights	Small Business Program	Engineered_Existing

Measure	Program	Adoption Curve
LED light Bulb- LED MR16 lamp	Small Business Program	Engineered_Existing
Reduced Wattage T8 fixtures - Three-lamped reduced wattage T-8 fixtures	Retrofit Program	Engineered_Existing
T5 Fixtures	Retrofit Program	Engineered_Existing
Reduced Wattage T-8 re-lamping (28W T8) replacing 3 32W T-8	Small Business Program	Engineered_Existing
Integral LED Troffers- 2'X 4' LED Troffer	Retrofit Program	Engineered_Existing
T8/T5 Replacement - 4 - 4' 54 W T5 High Output Fixture	Retrofit Program	Engineered_Existing
T8/T5 Replacement - 4 - 4' 32W HBF	Retrofit Program	Engineered_Existing
Energy Star LED Par 16-20-38- Lamps E26 Base	Small Business Program	Engineered_Existing
Energy Star LED Lamps PAR16 MR16 GU10 base	Small Business Program	Engineered_Existing
Energy Star LED Lamps MR16 Gu 5.3 base	Small Business Program	Engineered_Existing
9 W Exit Sign Retrofit: CFL replacing Incandescent	Small Business Program	SBL Other_Existing
Cold Cathode Screw-In Bulb	Retrofit Program	Custom_Existing
LED Exit sign single sided (5W)	Small Business Program	SBL Other_Existing
Photoluminescent Exit Sign	Retrofit Program	Prescriptive_Existing
Sel Ballasted Ceramic Metal Halide Lamp	Retrofit Program	Engineered_Existing
Lower Wattage HID lamps- 320 W Pulse Start Metal Halide	Retrofit Program	Engineered_Existing
Lower Wattage HID lamps- 400 W Pulse Start Metal Halide	Retrofit Program	Engineered_Existing
High Performance Medium Bay T8 fixture	Retrofit Program	Engineered_Existing
High Performance Medium BayLED fixture	Retrofit Program	Engineered_Existing
T5 Medium and High Bay Fixtures 8 lamp HO T5 fixture	Retrofit Program	Engineered_Existing
Metal Halide Direct Lamp Replacement 360W Metal Halide	Retrofit Program	Engineered_Existing
Induction High Bay Lighting	Retrofit Program	Custom_Existing
15 HP ODP-High efficiency Motor (4 pole, 1800 rpm)	Retrofit Program	Engineered_Existing
75 HP ODP-High efficiency Motor (4 pole, 1800 rpm)	Retrofit Program	Engineered_Existing
150 HP ODP-High efficiency Motor (4 pole, 1800 rpm)	Retrofit Program	Engineered_Existing
15 HP TEFC-High efficiency Motor (4 pole, 1800 rpm)	Retrofit Program	Engineered_Existing
75 HP TEFC-High efficiency Motor (4 pole, 1800 rpm)	Retrofit Program	Engineered_Existing
150 HP TEFC-High efficiency Motor (4 pole, 1800 rpm)	Retrofit Program	Engineered_Existing
Synchronous Belt: Motor Size: 5 HP, 73.5% Load Factor	Retrofit Program	Engineered_Existing
Synchronous Belt: Motor Size: 15 HP, 73.5% Load Factor	Retrofit Program	Engineered_Existing
Synchronous Belt: Motor Size: 75 HP, 73.5% Load Factor	Retrofit Program	Engineered_Existing
Variable Speed Drive Control, 5HP	Retrofit Program	Engineered_Existing
Variable Speed Drive Control, 20 HP	Retrofit Program	Engineered_Existing
Variable Speed Drive Control, 50 HP	Retrofit Program	Engineered_Existing
ENERGY STAR® Clothes Washer	Retrofit Program	Prescriptive_Existing
Energy Star Dishwasher	Retrofit Program	Prescriptive_Existing
ENERGY STAR Ice Machines-Ice Making Head	Retrofit Program	Custom_Existing

Measure	Program	Adoption Curve
ENERGY STAR Ice Machines-Remote Condesing Unit (w.o Remote Compressor)	Retrofit Program	Custom_Existing
ENERGY STAR Ice Machines-Remote Condesing Unit (w. Remote Compressor)	Retrofit Program	Custom_Existing
ENERGY STAR Ice Machines-Self Contained Unit	Retrofit Program	Prescriptive_Existing
ENERGY STAR® Televisions	Retrofit Program	Prescriptive_Existing
ENERGY STAR® Water Coolers	Retrofit Program	Custom_Existing
ENERGY STAR Battery Charger	Retrofit Program	Custom_Existing
ENERGY STAR External Power Adapter	Retrofit Program	Custom_Existing
ENERGY STAR Freezer-Glass Door	Retrofit Program	Custom_Existing
ENERGY STAR Freezer-Solid Door	Retrofit Program	Custom_Existing
ENERGY STAR Refrigerator-Glass Door	Retrofit Program	Custom_Existing
ENERGY STAR Refrigerator-Solid Door	Retrofit Program	Custom_Existing
Walk-in Shaded Pole to ECM Evaporator Fan Motor	Retrofit Program	Engineered_Existing
Walk-in PSC to ECM Evaporator Fan Motor	Retrofit Program	Engineered_Existing
High Efficiency Refrigeration Compressors-Discus	Retrofit Program	Custom_Existing
High Efficiency Refrigeration Compressors-Scroll	Retrofit Program	Custom_Existing
Efficient compressor motor	Retrofit Program	Engineered_Existing
Energy STAR Refrigerated Beverage Vending Machine (Class-A)	Retrofit Program	Custom_Existing
Energy STAR Refrigerated Beverage Vending Machine (Class-B)	Retrofit Program	Custom_Existing
Reach-in PSC to ECM Evaporator Fan Motor	Retrofit Program	Engineered_Existing
Reach-in Shaded Pole to ECM Evaporator Fan Motor	Retrofit Program	Engineered_Existing
Reach-in Shaded Pole to PSC Evaporator Fan Motor	Retrofit Program	Engineered_Existing
VSD Controlled Compressor	Retrofit Program	Engineered_Existing
VSD Air Compressor	Retrofit Program	Engineered_Existing
Facility Commissioning	Audit and Energy Partners Program	Custom_Existing
Re-Commissioning (Existing Construction)	Audit and Energy Partners Program	Custom_Existing
Data Center-Server/Storage Consolidation	Retrofit Program	Custom_Existing
Data Center-Server/Storage Virtualization	Retrofit Program	Custom_Existing
Solid-state temperature controls	Retrofit Program	Custom_Existing
Chiller Tuneup/Diagnostics	Retrofit Program	Custom_Existing
Cooling Tower Optimization	Audit and Energy Partners Program	Custom_New
Active Chilled Beam Cooling	Retrofit Program	Custom_Existing
Chilled Water Reset, Optimizer System for Chiller(s)	Audit and Energy Partners Program	Custom_New
Hi Eff HVAC Design	Audit and Energy Partners Program	Custom_New

Measure	Program	Adoption Curve
DX Coil Clean	Retrofit Program	Custom_Existing
HVAC Diagnostic/Air Conditioner Tune Up	Retrofit Program	Custom_Existing
Adding reflective (White) roof treatment	Retrofit Program	Custom_Existing
Adding window shade film	Retrofit Program	Custom_Existing
Adding window shade screen	Retrofit Program	Custom_Existing
Automated control system	Retrofit Program	Custom_Existing
Ceiling Insulations (R25 Code to R30)	Retrofit Program	Custom_Existing
Ceiling Insulations (R25 Code to R35)	Retrofit Program	Custom_Existing
Ceiling Insulations (R25 Code to R40)	Retrofit Program	Custom_Existing
Energy Recovery Ventilation Systems	Retrofit Program	Engineered_Existing
Duct Insulation R-8	Retrofit Program	Custom_Existing
Green (living) Roof (New construction or roof replacement)	Retrofit Program	Custom_Existing
Programmable Thermostat (7 Day, 2 Stage Setback)	Small Business Program	Prescriptive_Existing
Wall Insulations (R23 to R30)	Retrofit Program	Custom_Existing
Wall Insulations (R23 to R38)	Retrofit Program	Custom_Existing
Wall Insulations (R10 to R30)	Retrofit Program	Custom_Existing
HVAC Diagnostic Tune Up	Retrofit Program	Custom_Existing
Notched V Belts for HVAC Systems	Retrofit Program	Custom_Existing
Demand controlled Circulating Systems	Retrofit Program	Custom_Existing
Drainwater Heat Recovery Water Heater	Retrofit Program	Engineered_Existing
Faucet Aerators	Small Business Program	Prescriptive_Existing
Heat Recovery Unit	Retrofit Program	Engineered_Existing
Heat Trap	Retrofit Program	Engineered_Existing
Hot Water (DHW) Pipe Insulation	Small Business Program	Engineered_Existing
Hot Water Circulation Pump Time Clock	Retrofit Program	Custom_Existing
Insulating Tank Wrap on Water Heater (R-11)	Small Business Program	Prescriptive_Existing
Low Flow Pre-Rinse Sprayers	Retrofit Program	Prescriptive_Existing
Low-Flow Showerhead	Retrofit Program	Prescriptive_Existing
Ultrasonic Faucet Control	Retrofit Program	Custom_Existing
Water Heater Thermostat Setback	Small Business Program	Custom_Existing
Humidification w/ High pressure, Ultrasonic devices	Retrofit Program	Custom_Existing
Energy Efficient Laboratory Fume Hood	Retrofit Program	Custom_Existing
CO sensors for parking garage exhaust fans	Retrofit Program	Custom_Existing
Photocell Dimming Control (Outdoors)	Retrofit Program	Prescriptive_Existing
Occupancy Sensor	Retrofit Program	Engineered_Existing
Indoor Daylight Sensors	Retrofit Program	Engineered_Existing
Photocell Dimming Control (Interior)	Retrofit Program	Engineered_Existing
Auto Off Time Switch	Retrofit Program	Engineered_Existing

Measure	Program	Adoption Curve
Central Lighting Control System	Retrofit Program	Custom_Existing
Time Clock Control	Retrofit Program	Engineered_Existing
Downsizing motor during retrofit	Audit and Energy Partners Program	Custom_New
Escalator Motor Controller	Retrofit Program	Custom_Existing
Fan Motor - correct sizing	Audit and Energy Partners Program	Custom_New
Beverage Machine Control	Retrofit Program	Custom_Existing
Air curtain technology	Retrofit Program	Engineered_Existing
Anti-Sweat Heat Controls-Cooler	Retrofit Program	Engineered_Existing
Anti-Sweat Heat Controls-Freezer	Retrofit Program	Engineered_Existing
Auto Closer on Refrigerator Door	Retrofit Program	Custom_Existing
Demand Hot Gas Defrost	Retrofit Program	Custom_Existing
Door Gasket- Freezer	Retrofit Program	Custom_Existing
Door Gasket- Refrigerator	Retrofit Program	Custom_Existing
Economizer on Walk-In Cooler	Retrofit Program	Custom_Existing
eCube	Retrofit Program	Custom_Existing
Evaporator Coil Defrost Control (Cooler)	Retrofit Program	Engineered_Existing
Floating head pressure controller	Retrofit Program	Engineered_Existing
High R-Value Glass Doors	Retrofit Program	Custom_Existing
No-heat glass doors	Retrofit Program	Custom_Existing
Quick acting freezer doors	Retrofit Program	Custom_Existing
Refrigeration Commissioning	Audit and Energy Partners Program	Custom_New
Strip Curtains - Freezer	Retrofit Program	Prescriptive_Existing
Strip Curtains - Refrigerator	Retrofit Program	Prescriptive_Existing
Suction Pipe Insulation - Refrigerator	Retrofit Program	Custom_Existing
Vertical Night Covers for Display Cases	Retrofit Program	Engineered_Existing
Vendor Miser	Retrofit Program	Custom_Existing
Door Heater Controls for Coolers	Retrofit Program	Engineered_Existing
Door Heater Controls for Freezers	Retrofit Program	Engineered_Existing
Evaporator Fan Controls on Cooler	Retrofit Program	Engineered_Existing
Refrigeration Optimization	Audit and Energy Partners Program	Custom_New
Chilled Water Plant Optimization	Audit and Energy Partners Program	Custom_New
Business Energy Manager/Facility Audit	Audit and Energy Partners Program	Custom_Existing
High Efficiency Transformer	Retrofit Program	Custom_Existing

Industrial Sector

Measure	Program	Adoption Curve
VFD Controlled Compressor	Retrofit Program	Engineered_Existing
HE Compressor motors	Retrofit Program	Custom_Existing
Variable Displacement Air Compressor	Retrofit Program	Custom_Existing
Efficient Compressed Air Nozzles	Retrofit Program	Custom_Existing
Dual Exhaust Ventilation System	Retrofit Program	Custom_Existing
UNITARY AIR-CONDITIONING UNIT - Split system < 5.4 tons, Electric Resistance, 12.5 EER (per ton)	Retrofit Program	Engineered_Existing
UNITARY AIR-CONDITIONING UNIT - Split system < 5.4 tons, All Other, 12.5 EER (per ton)	Retrofit Program	Engineered_Existing
UNITARY AIR-CONDITIONING UNIT - Single package < 5.4 tons, All Other, 12.0 EER (per ton)	Retrofit Program	Engineered_Existing
UNITARY AIR-CONDITIONING UNIT - Split system/Single package ≥ 20 to < 63 tons, Electric Resistance, 10.8 EER (per ton)	Retrofit Program	Engineered_Existing
UNITARY AIR-CONDITIONING UNIT - Split system/Single package ≥ 20 to < 63 tons, All Other, 10.6 EER (per ton)	Retrofit Program	Engineered_Existing
UNITARY AIR-CONDITIONING UNIT WITH ECONOMIZER - Single package, ≥ 5.4 to ≤ 7.5 tons, Electric Resistance, 12.2 EER (per ton)	Retrofit Program	Engineered_Existing
ECM MOTORS FOR HVAC APPLICATION (FAN-POWERED VAV BOX) - VAV Units	Retrofit Program	Engineered_Existing
ECM MOTORS FOR HVAC APPLICATION (FAN MOTOR REPLACEMENT	Retrofit Program	Engineered_Existing
ECM MOTORS FOR HVAC APPLICATION (FAN MOTOR REPLACEMENT - Motor ≥ 1 hp	Retrofit Program	Engineered_Existing
Ductless Heat Pump	Retrofit Program	Engineered_Existing
Ground Source Heat Pump (Closed Loop)	Retrofit Program	Engineered_Existing
Ground Source Heat Pump (Open Loop)	Retrofit Program	Engineered_Existing
High Efficiency Air Cooled Chiller, 100 Tons	Retrofit Program	Engineered_Existing
High Efficiency Air Cooled Chiller, 130 Tons	Retrofit Program	Engineered_Existing
High Efficiency Air Source Heat Pump (12 EER, 3.6 COP)	Retrofit Program	Engineered_Existing
High Efficiency Water Cooled Centrifugal Chiller, 175 Tons	Retrofit Program	Engineered_Existing
High Efficiency Water Cooled Centrifugal Chiller, 300 Tons	Retrofit Program	Engineered_Existing
High Efficiency Water Cooled Centrifugal Chiller, 500 Tons	Retrofit Program	Engineered_Existing
High Efficiency Water Cooled Centrifugal Chiller, 600 Tons	Retrofit Program	Engineered_Existing
High Efficiency Water Cooled Reciprocating Chiller, 100 Tons	Retrofit Program	Engineered_Existing
High Efficiency Water Cooled Reciprocating Chiller, 175 Tons	Retrofit Program	Engineered_Existing
High Efficiency Water Cooled Reciprocating Chiller, 300 Tons	Retrofit Program	Engineered_Existing
High Efficiency Water Cooled Reciprocating Chiller, 50 Tons	Retrofit Program	Engineered_Existing
Variable Refrigerant Flow Heat Pump	Retrofit Program	Engineered_Existing
VFD on Cooling Tower Fan	Retrofit Program	Custom_Existing
Water Source Heat Pump (4 ton)	Retrofit Program	Engineered_Existing
Outside Air Economizer	Retrofit Program	Prescriptive_Existing

Measure	Program	Adoption Curve
T8 Lamps & Electronic Ballast	Small Business Program	SBL LED_Existing
Energy Star LED lamps- Omnidirectional A shape or Wet Location Rates Par 10W	Small Business Program	SBL LED_Existing
LED EXTERIROR AREA LIGHTS- LED FIXTURE (200W)	Retrofit Program	Prescriptive_Existing
LED Recessed Downlights	Retrofit Program	Engineered_Existing
LED light Bulb- LED MR16 lamp	Small Business Program	Engineered_Existing
LED LIGHT BULB - LED PAR lamp - 16W	Small Business Program	Prescriptive_Existing
REDUCED WATTAGE T8 FIXTURES - Three-lamp Reduced Watt. T-8 fixtures (25W)	Small Business Program	Prescriptive_Existing
HIGH PERFORMANCE MEDIUM BAY T8 FIXTURES - Four-lamp High Performance T-8 fixtures (32W)	Retrofit Program	Prescriptive_Existing
T5 FIXTURES	Retrofit Program	Prescriptive_Existing
T5 MEDIUM AND HIGH BAY FIXTURES - 8-lamp HO T-5 fixtures (54W)	Retrofit Program	Prescriptive_Existing
REDUCED WATTAGE T8 RE-LAMPING (28W T8) - Three 28W Lamps for Three Lamp Fixture	Small Business Program	Prescriptive_Existing
INTEGRAL LED TROFFERS - 2' x 4' LED troffer	Retrofit Program	Prescriptive_Existing
METAL HALIDE DIRECT LAMP REPLACEMENT - 1 – 360W Metal Halide Direct Lamp Replacement	Retrofit Program	Prescriptive_Existing
T8 / T5 REPLACEMENT - 4 – 4' 54W T5 High Output Fixture	Retrofit Program	Prescriptive_Existing
T8 / T5 REPLACEMENT – VAPOUR/DUST PROOF FIXTURE - 4 – 4' 32W HBF Vapour / Dust Proof Fixture (Minimum of 3,100 Lumens Per Lamp)	Retrofit Program	Prescriptive_Existing
ENERGY STAR® LED PAR16/20/30/38 LAMPS E26 BASE: 16 W	Small Business Program	Prescriptive_Existing
ENERGY STAR® LED LAMPS - PAR16 OR MR16 GU10 BASE: 7W	Small Business Program	Prescriptive_Existing
ENERGY STAR® LED LAMPS - MR16 GU5.3 BASE: 7W	Small Business Program	Prescriptive_Existing
Induction High Bay Lighting	Retrofit Program	Prescriptive_Existing
TOTALLY ENCLOSED FAN-COOLED (TEFC) MOTORS - TEFC 1800 RPM, <11 HP, 90%Eff	Retrofit Program	Prescriptive_Existing
TOTALLY ENCLOSED FAN-COOLED (TEFC) MOTORS - TEFC 1800 RPM, 11 - 100 HP, 94%Eff	Retrofit Program	Prescriptive_Existing
TOTALLY ENCLOSED FAN-COOLED (TEFC) MOTORS - TEFC 1800 RPM, >100 HP, 95.8%Eff	Retrofit Program	Prescriptive_Existing
High Efficiency Ventilation Exhaust Fans	Retrofit Program	Prescriptive_Existing
High Volume Low Speed Fan	Retrofit Program	Prescriptive_Existing
Circulating Fans	Retrofit Program	Custom_Existing
Properly Sized Fans	Audit and Energy Partners	Custom_Existing
Efficient Centrifugal Fan		Custom_Existing

Measure	Program	Adoption Curve
OPEN DRIP-PROOF (ODP) MOTORS - ODP 1800 RPM, < 26 HP 90%Eff		Prescriptive_Existing
OPEN DRIP-PROOF (ODP) MOTORS - ODP 1800 RPM, 40 - 124 HP, 95%Eff	Retrofit Program	Prescriptive_Existing
OPEN DRIP-PROOF (ODP) MOTORS - ODP 1800 RPM, > 125 HP, 96%Eff	Retrofit Program	Prescriptive_Existing
SYNCHRONOUS BELT - Motor Size: <10 HP, 73.5% Load Factor	Retrofit Program	Prescriptive_Existing
SYNCHRONOUS BELT - Motor Size: 10 - 50 HP, 73.5% Load Factor	Retrofit Program	Prescriptive_Existing
SYNCHRONOUS BELT - Motor Size: >50 HP, 73.5% Load Factor	Retrofit Program	Prescriptive_Existing
VARIABLE FREQUENCY DRIVE (VFD) - Motor Size: <10 HP, 66% Load Factor	Retrofit Program	Prescriptive_Existing
VARIABLE FREQUENCY DRIVE (VFD) - Motor Size: 10-50 HP, 66% Load Factor	Retrofit Program	Prescriptive_Existing
VARIABLE FREQUENCY DRIVE (VFD) - Motor Size: >50 HP, 66% Load Factor	Retrofit Program	Prescriptive_Existing
Standard to Cogged Belt on Motors 1-25 HP	Retrofit Program	Custom_Existing
Standard to Cogged Belt on Motors 30-500 HP	Retrofit Program	Custom_Existing
Pneumatic Motors Replacement with Electric Motors	Retrofit Program	Custom_Existing
Motors Improvements	Retrofit Program	Custom_Existing
Material Handling Improvements	Retrofit Program	Custom_Existing
Material Handling VFD	Retrofit Program	Custom_Existing
Switch from Belt drive to Direct Drive	Retrofit Program	Custom_Existing
Low Energy Livestock Waterer	Retrofit Program	Custom_Existing
Automatic Milker Takeoff	Retrofit Program	Custom_Existing
High Efficiency Medium Voltage Dry-type, Single-Phase Transformers	Retrofit Program	Custom_Existing
High Efficiency Liquid Immersed, Single-Phase Transformers	Retrofit Program	Custom_Existing
3- Phase High Frequency Battery Charger	Retrofit Program	Custom_Existing
3- Phase High Frequency Battery Charger - 2 shift	Retrofit Program	Custom_Existing
3- Phase High Frequency Battery Charger - 3 shifts	Retrofit Program	Custom_Existing
Elec Chip Fab - Solidstate Chiller	Retrofit Program	Custom_Existing
Milk Precooler - Dairy Plate Cooler	Retrofit Program	Custom_Existing
Adjustable speed drive on compressors	Retrofit Program	Prescriptive_Existing
Efficient Refrigeration Condenser	Retrofit Program	Custom_Existing
Scroll Compressor > 10.5 EER with heat excahnger for dairy refrigeration	Retrofit Program	Custom_Existing
Scroll Compressor > 10.5 EER without heat excahnger for dairy refrigeration	Retrofit Program	Custom_Existing
Single Creep Pad	Retrofit Program	Custom_Existing
Double Creep Pad	Retrofit Program	Custom_Existing
Heat of Compression Air Dryer	Retrofit Program	Custom_Existing

Measure	Program	Adoption Curve
Metal - New Arc Furnace	Retrofit Program	Custom_Existing
Heat Lamps	Retrofit Program	Custom_Existing
Dual Exhaust Ventilation System Dairy	Retrofit Program	Custom_Existing
HE Stock Tank	Retrofit Program	Custom_Existing
High Efficiency Grain Dryers	Retrofit Program	Custom_Existing
Kraft - Efficient Agitator	Retrofit Program	Custom_Existing
Kraft - Effluent Treatment System	Retrofit Program	Custom_Existing
Mech pulp refiner replacement	Retrofit Program	Custom_Existing
Paper - Efficient Pulp Screen	Retrofit Program	Custom_Existing
Heated Desiccant Air Dryer on VSD Compressor	Retrofit Program	Custom_Existing
Heat Exchanger upgrades for product cooling	Retrofit Program	Custom_Existing
Free Cooling and New A/C Units	Retrofit Program	Custom_Existing
Variable Air Volume Conversion Project	Retrofit Program	Custom_Existing
Energy Efficient Refrigeration Unit	Retrofit Program	Custom_Existing
Heated Desiccant Air Dryer on VD Compressor	Retrofit Program	Custom_Existing
Heated Desiccant Air Dryer on LNL Compressor	Retrofit Program	Custom_Existing
Blower Purge Desiccant Air Dryer on VSD Compressor	Retrofit Program	Custom_Existing
Blower Purge Desiccant Air Dryer on VD Compressor	Retrofit Program	Custom_Existing
Blower Purge Desiccant Air Dryer on LNL Compressor	Retrofit Program	Custom_Existing
Ventilation System Optimization	Audit and Energy Partners	Custom_Existing
Induction Street Lighting	Retrofit Program	Engineered_Existing
Green LED Traffic Light	Retrofit Program	Engineered_Existing
Red LED Traffic Light	Retrofit Program	Engineered_Existing
Yellow LED Traffic Light	Retrofit Program	Engineered_Existing
Green Arrow LED Traffic Light	Retrofit Program	Engineered_Existing
Red Arrow LED Traffic Light	Retrofit Program	Engineered_Existing
Yellow Arrow LED Traffic Light	Retrofit Program	Engineered_Existing
LED Parking Lot Fixture	Retrofit Program	Engineered_Existing
LED Street Light Fixture	Retrofit Program	Engineered_Existing
Recommissioning / Facility Energy Management	Audit and Energy Partners	Custom_Existing
Integrated Plant Energy Management	Audit and Energy Partners	Custom_Existing
Zero Loss Condensate Drain	Retrofit Program	Custom_Existing
Air Compressor Demand Reduction	Retrofit Program	Custom_Existing
Improved Controls - Air Compressor	Retrofit Program	Custom_Existing
Air Leak Survey and Repair	Retrofit Program	Custom_Existing
Low Pressure-drop Filters	Retrofit Program	Custom_Existing

Measure	Program	Adoption Curve
Outside Air Intake	Retrofit Program	Custom_Existing
Receiver Capacity Addition	Retrofit Program	Custom_Existing
Air Compressor Optimization	Audit and Energy Partners	Custom_Existing
Head Pressure Control	Retrofit Program	Custom_Existing
Ceiling Insulations (R25 Code to R30)	Retrofit Program	Custom_Existing
Ceiling Insulations (R25 Code to R35)	Retrofit Program	Custom_Existing
Ceiling Insulations (R25 Code to R40)	Retrofit Program	Custom_Existing
Chiller Tuneup/Diagnostics	Retrofit Program	Custom_Existing
Cooling Tower Optimization	Audit and Energy Partners	Custom_Existing
Duct Insulation, Add R8	Retrofit Program	Custom_Existing
DX Coil Cleaning	Retrofit Program	Custom_Existing
HVAC Diagnostic/Air Conditioner Tune Up	Retrofit Program	Custom_Existing
Improved Controls - HVAC	Retrofit Program	Custom_Existing
Wall Insulations (Going from R23 to R30)	Retrofit Program	Custom_Existing
Wall Insulations (Going from R23 to R38)	Retrofit Program	Custom_Existing
Wall Insulations (Going from R10 to R30)	Retrofit Program	Custom_Existing
Heat Reclaimer	Retrofit Program	Custom_Existing
Heat Recovery Ventilators	Retrofit Program	Custom_Existing
Programmable Ventilation Controller	Retrofit Program	Custom_Existing
Building Shell Improvements	Retrofit Program	Custom_Existing
Automatic High Speed Doors - Exterior	Retrofit Program	Custom_Existing
Occupancy Sensor	Retrofit Program	Custom_Existing
OCCUPANCY SENSORS - Ceiling mounted	Retrofit Program	Custom_Existing
PHOTOCELL AND TIMER FOR LIGHTING CONTROL	Retrofit Program	Custom_Existing
Central Lighting Control System	Retrofit Program	Custom_Existing
Indoor Daylight Sensors	Retrofit Program	Custom_Existing
Lighting System Design Optimization	Audit and Energy Partners	Custom_Existing
Improved Controls - Fans	Retrofit Program	Custom_Existing
Improved Controls - Motors	Retrofit Program	Custom_Existing
Motor Management Plan	Audit and Energy Partners	Custom_Existing
Pump Equipment Upgrade	Retrofit Program	Custom_Existing
Pump System Optimization	Audit and Energy Partners	Custom_Existing
Greenhouse Heat Curtain	Retrofit Program	Custom_Existing
High Efficiency Welders	Retrofit Program	Custom_Existing
Clean Room - Change Filter Strategy	Retrofit Program	Custom_Existing

Measure	Program	Adoption Curve
Clean Room - Chiller Optimize	Audit and Energy Partners	Custom_Existing
Clean Room - Clean Room HVAC	Retrofit Program	Custom_Existing
Improved Controls - Process Cooling	Retrofit Program	Custom_Existing
Cold Storage Retrofit	Retrofit Program	Custom_Existing
Cold Storage Tuneup	Retrofit Program	Custom_Existing
Pellet Dryer Tanks and Ducts 3 dia	Retrofit Program	Custom_Existing
Refrigerated Cycling Dryers	Retrofit Program	Custom_Existing
Dew Point Sensor Control for Desiccant CA Dryer	Retrofit Program	Custom_Existing
Process Cooling Ventilation Reduction- fan hp	Retrofit Program	Custom_Existing
Automatic High Speed Doors- freezer	Retrofit Program	Custom_Existing
Automatic High Speed Doors- Cooler	Retrofit Program	Custom_Existing
Automatic High Speed Doors- Between cooler and dock	Retrofit Program	Custom_Existing
Dairy Refrigeration Tune-up	Retrofit Program	Custom_Existing
High Temperature Cutout Thermostat	Retrofit Program	Custom_Existing
Creep Heat Controller	Retrofit Program	Custom_Existing
Block Heater Timer	Retrofit Program	Custom_Existing
Improved Controls - Process Heating	Retrofit Program	Custom_Existing
Process Heat O&M	Retrofit Program	Custom_Existing
Heat Lamp Setback (Microzone)	Retrofit Program	Custom_Existing
Heat Lamp - Heating Pad Controller	Retrofit Program	Custom_Existing
Grain bin aeration control systems	Retrofit Program	Custom_Existing
Elec Chip Fab - Eliminate Exhaust	Retrofit Program	Custom_Existing
Elec Chip Fab: Exhaust Injector	Retrofit Program	Custom_Existing
Elec Chip Fab - Reduce Gas Pressure	Retrofit Program	Custom_Existing
Mech Pulp - Premium Process	Retrofit Program	Custom_Existing
Mech Pulp - Refiner Plate Improvement	Retrofit Program	Custom_Existing
Barrel Insulation - Plastic Injection Molding and Extrusion Machine Barrels	Retrofit Program	Custom_Existing
Chiller Optimization	Audit and Energy Partners	Custom_Existing
Process Optimization	Audit and Energy Partners	Custom_Existing
Leed New Construction Whole Building Design	C&I New Construction	Engineered_Existing
Infrared Film for Greenhouses	Retrofit Program	Custom_Existing
Fan Thermostat Controller	Retrofit Program	Custom_Existing
Drip Irrigation Nozzles	Retrofit Program	Custom_Existing
Scientific Irrigation System (SIS)	Retrofit Program	Custom_Existing

Appendix C: Methodology to Calculate Achievable Potential

This appendix provides a description of the methodology that was used to develop the adoption curves and the calculation to derive achievable potential savings. See the report for the short term analysis regarding discussion of archetype programs and LDC Profiles.

Development of Adoption Curves

Adoption curves were developed to estimate the achievable annual participation in each archetype program from 2015 to 2020. The estimated participation is used in the model to derive the estimated achievable potential savings for each archetype program. Key items that were taken into consideration in developing and applying the adoption curves include:

- Historic prog am participation
- Transition from previous framework to CFF
- Design and launch period for new/enhanced programs
- Non-incentive influences

An adoption curves represents the percentage of participation of eligible customers in a program, and as illustrated in Figure C-1, adoption curves typically includes:

- A program launch period.
- An accelerated increase in participation until a peak participation rate is reached.
- A decreased in accelerated participation and plateau as maximum participation is approached.

Programs that were launched and delivered in Ontario during the previous framework will have moved passed the launch period and will be on a slope of increased participation. As illustrated in Figure C-2 the analysis for this study will start in 2015. New programs to be launched during the Conservation First Framework will start at the beginning of the launch period. Program enhancements can be implemented to accelerate the rate of participation, as illustrated in Figure C-3.

The adoption curves were developed using the equation derived by the Bass diffusion theory and historic program participation, as illustrated in Figure C-4.

Figure C-1: Adoption Curve Concepts

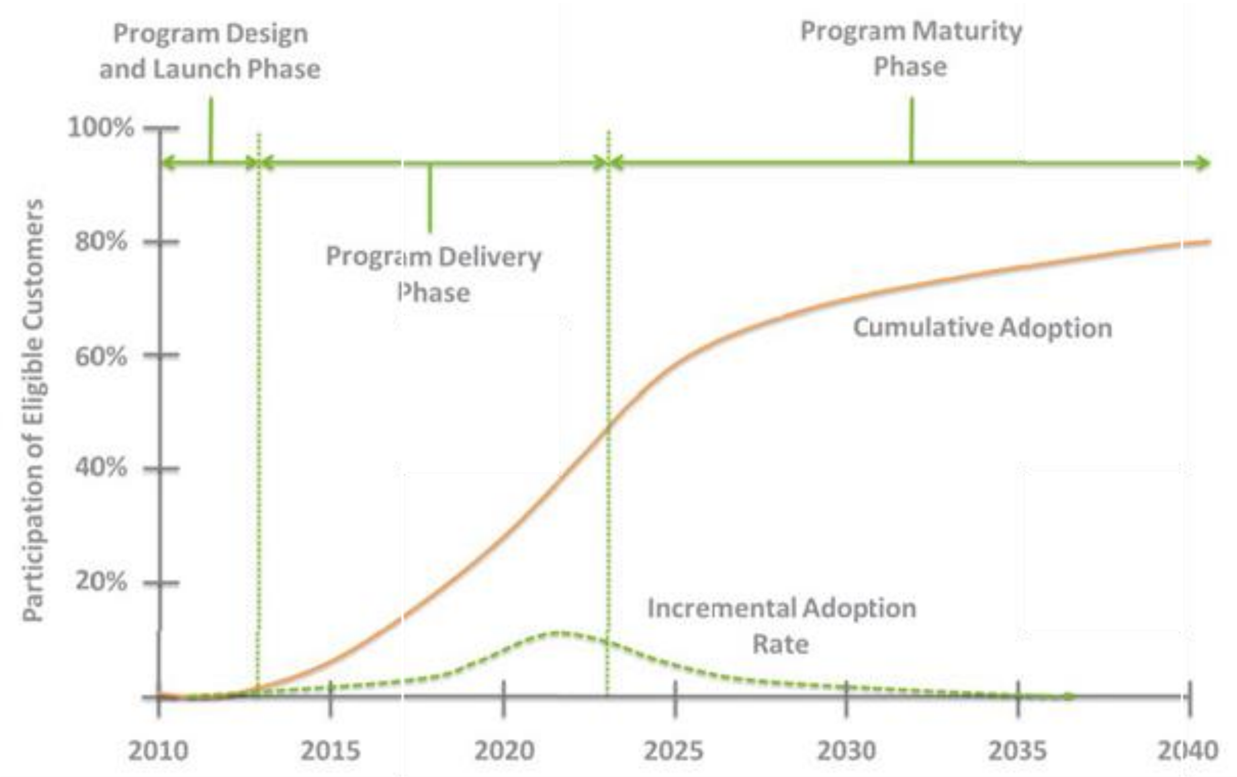


Figure C-2: 2015 as First Year of Potential Savings

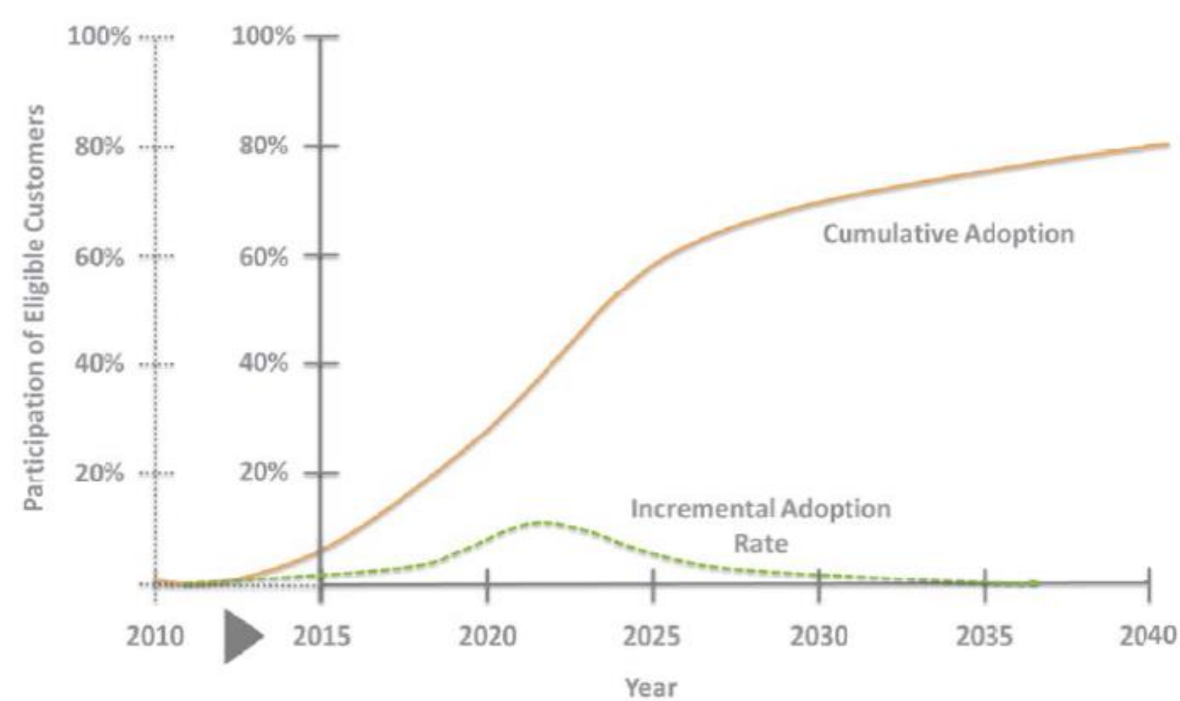


Figure C-3: Accelerated Take Up Due to Program Enhancements

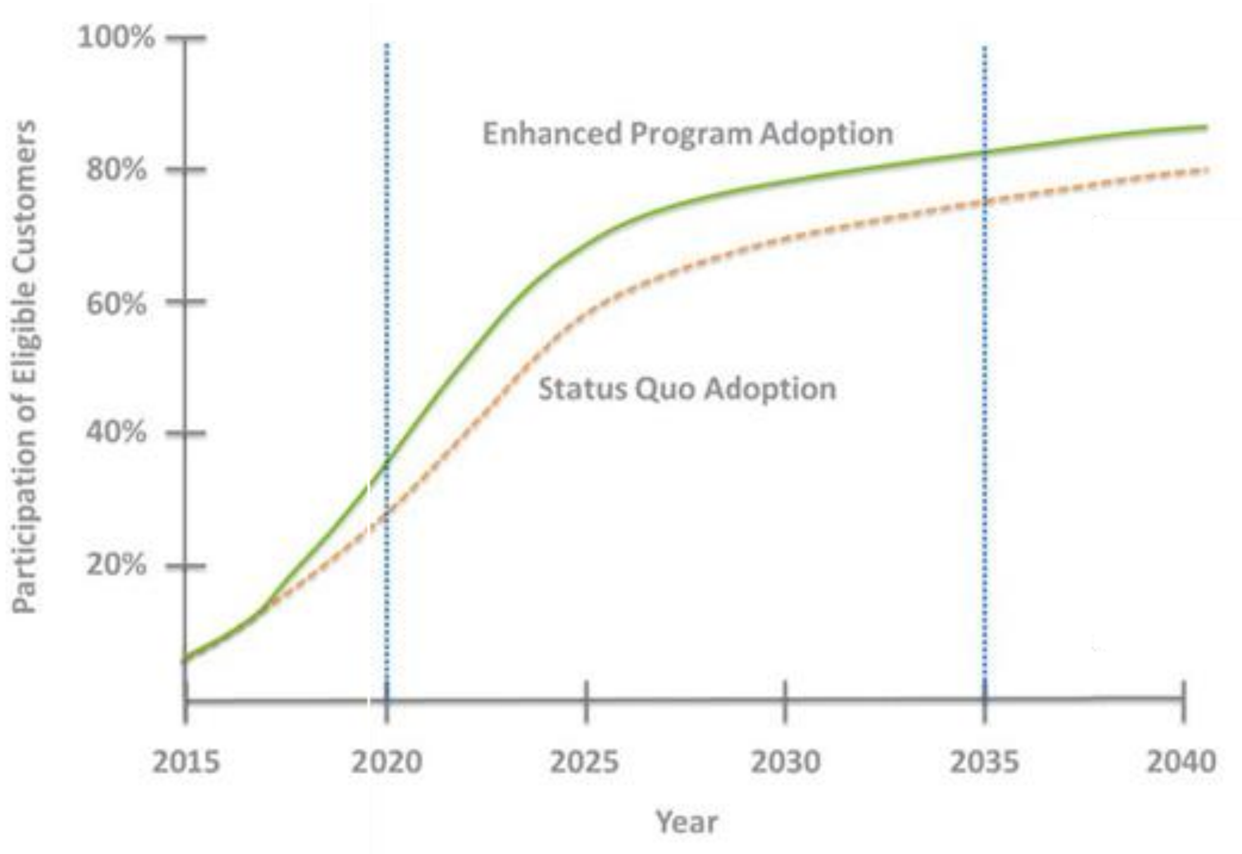
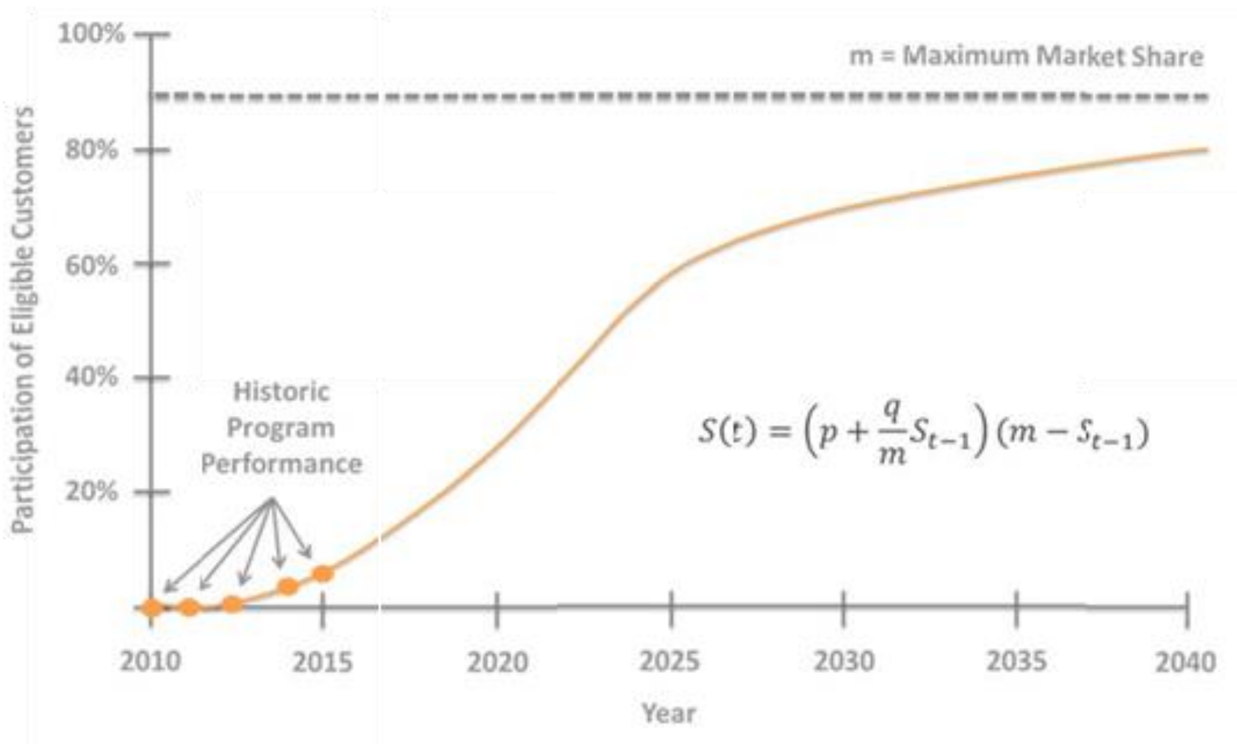


Figure C-4: Adoption Curved Based on Bass Diffusion Model and Historic Program Participation



In the Bass diffusion equation S(t) is the market share (or participation) in the current year, while S_{t-1} is the market share (or participation) up to the previous year.

The following parameters are used in the Bass discussion equation:

p = coefficient of innovation

- Accounts for external effects
- An external effect where program archetypes can influence adoption

q = coefficient of imitation

- Accounts for internal effects
- Considered as an inherent property of the market and technology

m = maximum market share of eligible population

Eligible population was developed as part of developing each LDC's energy use profile, using:

- Total population
- End use saturation
- End use fuel share
- Equipment measure life

Eligible population is the fraction of total population based on average measure life by equipment type. Equipment type average measure life is the average measure life of all measures associated with an equipment type. For example, the equipment type commercial interior lighting includes various kinds of lighting measures. The average life of these measures defines the equipment type average measure life. The following equation is used to derive the eligible population:

$$\text{Eligible Population} = \frac{1}{\text{Equipment Type Average Measure Life}} \times (\text{Total Population})$$

Total population is the product of premise counts, end use saturation and end use fuel share. Where end use saturation is the percentage of households with the end use present and end use fuel share is the percentage of households with the end use present that are electric fueled.

$$\text{Total Population} = (\text{Premise Count}) \times (\text{End Use Saturation}) \times (\text{End Use Fuel Share})$$

Historic Ontario program participation data for 2011 to 2014 was used to derive the Ontario market adoption curves. A sample of the data set is provided in Table C-1. Market adoption curves were aligned with availability of historic program participation data as summarized in Table C-2.

Table C-1: Sample Data Set of Historic Program Participation

LDC	Year	Measure	Units	Eligible Population
LDC 1	2011	ECM	26	6,953
LDC 1	2012	ECM	19	6,953
LDC 1	2013	ECM	83	6,953
LDC 1	2014	ECM	84	6,953
LDC 1	2011	Tier 1 CAC	0	302
LDC 1	2013	Tier 1 CAC	1	302
LDC 1	2014	Tier 1 CAC	1	302
LDC 1	2011	Tier 2 CAC	1	302
LDC 1	2014	Tier 2 CAC	6	302
LDC 2	2011	ECM	1	1,477
LDC 2	2013	ECM	2	1,477
LDC 2	2014	ECM	3	1,477
LDC 2	2011	Tier 1 CAC	0	295
LDC 2	2011	Tier 2 CAC	0	295
LDC 2	2013	Tier 2 CAC	1	295
LDC 3	2011	ECM	900	35,419
LDC 3	2012	ECM	554	35,419
LDC 3	2013	ECM	487	35,419
LDC 3	2014	ECM	587	35,419
LDC 3	2011	Tier 1 CAC	134	20,381
LDC 3	2012	Tier 1 CAC	55	20,381
LDC 3	2013	Tier 1 CAC	57	20,381
LDC 3	2014	Tier 1 CAC	46	20,381
LDC 3	2011	Tier 2 CAC	384	20,381
LDC 3	2013	Tier 2 CAC	343	20,381
LDC 3	2014	Tier 2 CAC	428	20,381
LDC 4	2011	ECM	178	7,868
LDC 4	2012	ECM	147	7,868
LDC 4	2013	ECM	126	7,868
LDC 4	2014	ECM	145	7,868
LDC 4	2011	Tier 1 CAC	47	5,849
LDC 4	2012	Tier 1 CAC	17	5,849
LDC 4	2013	Tier 1 CAC	16	5,849
LDC 4	2014	Tier 1 CAC	15	5,849
LDC 4	2011	Tier 2 CAC	66	5,849
LDC 4	2013	Tier 2 CAC	59	5,849
LDC 4	2014	Tier 2 CAC	78	5,849

Table C-2: Alignment of Adoption Curves with Available Historic Program Participation

Available Historic Participation Data by Measure / Program	Adoption Curve
Residential Sector	
Furnace with ECM	ECM
Tier 1 CAC	CACI
Tier 2 CAC	CACII
Outdoor clothesline umbrella stand or clothesline kits	Air dry
ENERGY STAR specialty and standard spiral CFL	CFL
Electric water heater blankets	DHW blanket
ENERGY STAR qualified ceiling fans	Fans
ENERGY STAR qualified fixtures	Fixture
ENERGY STAR general purpose and specialty LEDs	LED
Lighting control products	Light control
Hot water pipe wraps	Pipes
Advanced power bars	Powerbar
Weather stripping (foam or V-strip packages; door frame kits)	Shell
Electric baseboard programmable thermostats	Thermo
Heavy-duty outdoor timers	Timer
Window air conditioner pick-up (Home/Retailer)	Air conditioner
Dehumidifier pick-up (Home/Retailer)	Dehumidifier
Freezer pick-up (Home/Retailer)	Freezer
Fridge pick-up (Home/Retailer)	Refrigerator
Average adoption rate AC, dehumidifier, freezer and refrigerator measures	Miscellaneous appliances
Average adoption rate for all other measures' adoption curves	Miscellaneous all
75% adoption rate (Adjusted to achieve full savings in second year)	Home energy report (HER)
Commercial and Industrial Sectors	
LED (SBL Program)	Small business: CFL
CFL (SBL Program)	Small business: LED
Other lighting measures (SBL Program)	Small business: Other
Custom track measures (Retrofit Program)	Retrofit custom
Engineered track measures (Retrofit Program)	Retrofit engineered
Prescriptive track measures (Retrofit Program)	Retrofit prescriptive

22 Residential adoption curves were developed and 6 adoption curves were developed for commercial and industrial sectors. All the measures were mapped to the adoption curves and archetype programs as illustrated in Figure C-5 and the full list of mapping is provided in Appendix B: Mapping of EE Measures to Archetype Programs.

Figure C-5: Mapping of Measures to Adoption Curves and Archetype Programs

Sector	Measures	Adoption Curves	Archetype Programs
Residential	146	22	8
Commercial	207	6	4
Industrial	196	6	4

Table C-3: Market Adoption Curve Parameters from Historic Program Participation

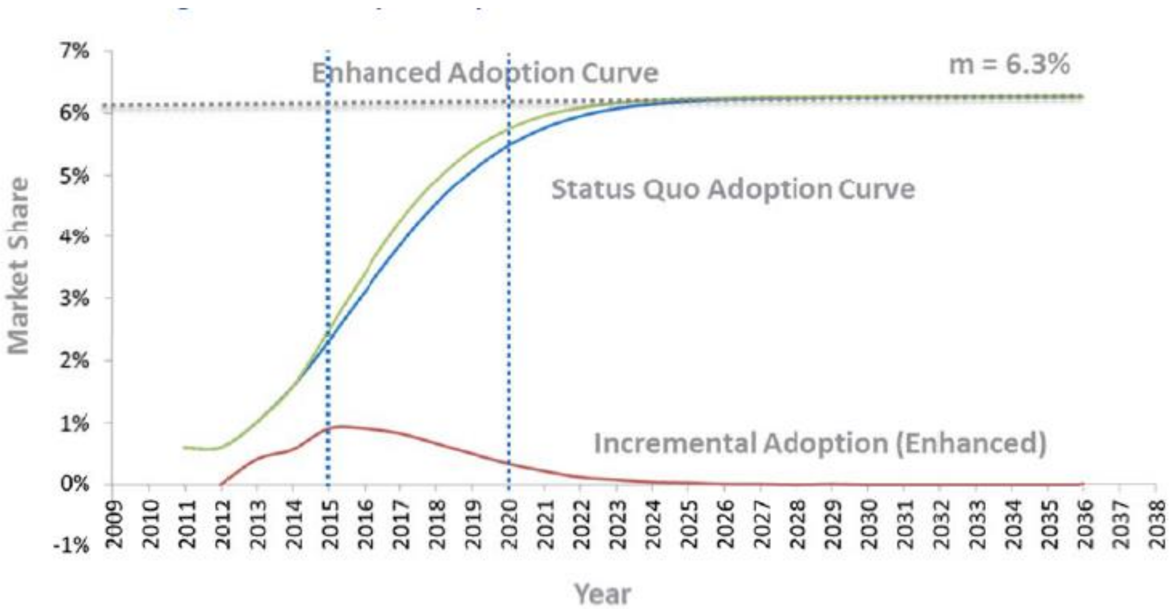
Adoption Curve	P	New p*	q	m
ECM	0.0348	0.0515	0.4081	14%
CACI	0.0334	0.0495	0.1048	8%
CACII	0.0327	0.0484	0.5688	9%
Air dry	0.0062	0.0065	0.3768	3%
CFL	0.0092	0.0098	0.2325	32%
DHW blanket	0.0050	0.0053	0.3489	1%
Fans	0.0087	0.0104	0.3065	1%
Fixture	0.0087	0.0104	0.3958	1%
LED	0.0092	0.0111	0.2325	32%
Light control	0.0122	0.0146	0.2730	12%
Pipes	0.0069	0.0073	0.2656	4%
Powerbar	0.0208	0.0220	0.2303	3%
Shell	0.0112	0.0214	0.2874	26%
Thermo	0.0070	0.0135	0.3444	4%
Timer	0.0103	0.0197	0.2509	6%
Air conditioner	0.0025	0.0030	0.2948	11%
Dehumidifier	0.0036	0.0043	0.1889	23%
Freezer	0.0026	0.0031	0.1043	47%
Refrigerator	0.0023	0.0028	0.0974	70%

Using the p, q and m parameters derived from the Ontario market analysis, the historic participation data of an LDC is used in the Bass diffusion equation to derive the incremental adoption rates. An example of the incremental adoption rates for Tier 2 CAC for an LDC is provided in Table C-4: Example of incremental Adoption Rates and the resulting adoption curves are illustrated in Figure C-6. The incremental adoption rates are used in the model.

Table C-4: Example of incremental Adoption Rates

Year	Status Quo Adoption Curve		Enhanced Adoption Curve	
	Market Share	Incremental Adoption	Enhanced Market Share	Incremental Adoption
2011	0.60%	0.60%	0.60%	0.60%
2012	0.60%	0.00%	0.60%	0.00%
2013	1.01%	0.41%	1.01%	0.41%
2014	1.58%	0.57%	1.58%	0.57%
2015	2.32%	0.74%	2.49%	0.91%
2016	3.10%	0.78%	3.40%	0.91%
2017	3.85%	0.75%	4.23%	0.83%
2018	4.52%	0.67%	4.90%	0.67%
2019	5.06%	0.54%	5.40%	0.50%
2020	5.47%	0.41%	5.74%	0.34%
2021	5.76%	0.29%	5.96%	0.22%
2022	5.95%	0.19%	6.08%	0.12%
2023	6.07%	0.12%	6.16%	0.08%
2024	6.14%	0.07%	6.20%	0.04%
2025	6.19%	0.05%	6.23%	0.03%
2026	6.22%	0.03%	6.24%	0.01%
2027	6.23%	0.01%	6.25%	0.01%
2028	6.24%	0.01%	6.25%	0.00%
2029	6.25%	0.01%	6.26%	0.01%
2030	6.25%	0.00%	6.26%	0.00%
2031	6.26%	0.01%	6.26%	0.00%
2032	6.26%	0.00%	6.26%	0.00%
2033	6.26%	0.00%	6.26%	0.00%
2034	6.26%	0.00%	6.26%	0.00%
2035	6.26%	0.00%	6.26%	0.00%
2036	6.26%	0.00%	6.26%	0.00%

Figure C-6: Example Adoption Curve for Tier 2 CAC for am LDC



When new measures are applied to existing programs, it is assumed that Year 1 and 2 of the adoption curves were program design and launch years, and it is not applicable to an individual measure. The provincial market adoption curve is applied to the new measure, starting in Year 3, as demonstrated in Table C-5.

Table C-5: Example of Adding a new Measure to an Existing Program

Provincial Adoption Curve: Fans		Measure: High Efficiency Bathroom Exhaust Fan	
Year	Incremental Adoption Rate	Year	Incremental Adoption Rate
Year 1	0.002%		N/A
Year 2	0.004%		N/A
Year 3	0.023%	2015	0.023%
Year 4	0.032%	2016	0.032%
Year 5	0.053%	2017	0.053%
Year 6	0.074%	2018	0.074%
Year 7	0.095%	2019	0.095%
Year 8	0.106%	2020	0.106%

Example Calculation of Achievable Potential

The steps in calculating achievable potential savings are illustrated with an example in the remainder of this appendix.

Step 1: LDC Specific Electricity Use Profile

LDC load profiles were developed with input from LDCs, and draft versions were reviewed with

LDCs to develop final versions. The LDC specific profile was developed and provides disaggregated load by sector, subsector, end use and equipment type, specific to each LDC.

An example of an LDC residential subsector profile:

Start Year Sales Distribution by Segment	
Segment	% of Start Yr Sales
Single Family	94%
Row House	3%
MURB Low Rise	2%
MURB High Rise	0%
Other Residential Buildings	2%
Total	100.00%

An example of LDC residential end use profile:

Start Year Sales Distribution by End Use																
	Space Heating	Space Cooling	Domestic Hot Water	Ventilation and Circulation	Lighting	Cooking	Refrigerators	Freezers	Clothes Washers	Clothes Dryers	Dishwashers	Plug Load	Dehumidifiers	Miscellaneous		Total
Single Family	21.2%	1.7%	14.8%	6.8%	9.5%	4.1%	6.7%	4.3%	0.6%	5.1%	0.8%	12.5%	1.1%	10.7%		100.0%
Row House	45.9%	1.2%	14.3%	3.3%	5.7%	2.9%	4.8%	2.6%	0.5%	3.0%	0.5%	9.5%	0.9%	5.1%		100.0%
MURB Low Rise	30.3%	1.5%	18.0%	5.2%	19.0%	3.7%	5.5%	2.5%	0.3%	1.2%	0.5%	9.9%	0.5%	2.0%		100.0%
MURB High Rise	25.0%	0.8%	18.2%	4.9%	22.9%	3.8%	5.5%	2.5%	0.3%	1.3%	0.5%	10.1%	0.5%	3.7%		100.0%
Other Residential Buildings	44.9%	1.4%	14.0%	2.6%	4.6%	3.3%	5.1%	3.3%	0.5%	3.6%	0.6%	10.4%		5.7%		100.0%
Must sum to 100% for each segment (column AD).																

Example of LDC profile by equipment type. The example provides the profiles for the first three subsectors in the model, namely single family, row house and MURB low rise.

TYPE
Utility
ipment Type Saturation
ent type saturation for all equipment types in all segments.

Lighting		Cooking		Refrigerators		Freezers	
Screw-in Lamps	100.0%	Oven	17.2%	Refrigerators	151.0%	Freezers	
Lighting Common Areas (MR)	5.0%	Range	94.3%				
Lighting Exterior	100.0%	Cooking Other	93.2%				
Lighting Other	100.0%						
Total Lighting	**305%**	**Total Cooking**	**205%**	**Total Refrigerators**	**151%**	**Total Freezers**	

Lighting		Cooking		Refrigerators		Freezers	
Screw-in Lamps	100.0%	Oven	17.2%	Refrigerators	115.0%	Freezers	
Lighting Common Areas (MR)	5.0%	Range	94.3%				
Lighting Exterior	100.0%	Cooking Other	93.2%				
Lighting Other	100.0%						
Total Lighting	**305%**	**Total Cooking**	**205%**	**Total Refrigerators**	**115%**	**Total Freezers**	

Lighting		Cooking		Refrigerators		Freezers	
Screw-in Lamps	100.0%	Oven	17.2%	Refrigerators	104.0%	Freezers	
Lighting Common Areas (MR)	100.0%	Range	94.3%				
Lighting Exterior	100.0%	Cooking Other	93.2%				
Lighting Other	100.0%						
Total Lighting	**400%**	**Total Cooking**	**205%**	**Total Refrigerators**	**104%**	**Total Freezers**	

Step 2: LDC Baseline Forecast and Load Share

Using load profiles and LDC kWh load forecasts, developed baseline forecast by sector, subsector, end use, equipment type, and vintage. This is used to define what share of the load measure savings is applied to.

Example of LDC load forecast for screw-in-lamps, lighting end use and single family subsector:

Scenario:	Segment:	End Use:	Equipment Type:	Measures ranked by:
AchBase	1	5	1	Total Resource Cost (TRC)
	Single Family	Lighting	Screw-in Lamps	

Screw-in Lamps Baseline Energy Sales Forecast	New	Turnover	Early Retirement	Remaining	Total
2015	32,6[illegible]	414,786	20,739	4,127,124	**4,595,289**
2016	32,839	328,292	16,579	3,960,190	**4,337,899**
2017	29,086	299,777	15,134	3,928,886	**4,272,883**
2018	25,884	273,076	13,783	3,888,640	**4,201,382**
2019	20,905	250,693	12,639	3,875,628	**4,159,865**
2020	16,547	229,613	11,563	3,853,759	**4,111,482**
2021	14,344	209,758	10,560	3,824,670	**4,059,331**
2022	11,903	192,156	9,667	3,805,469	**4,019,195**
2023	10,657	176,499	8,878	3,798,120	**3,994,154**
2024	9,327	162,049	8,149	3,788,726	**3,968,251**
2025	8,088	149,280	7,504	3,791,819	**3,956,691**
2026	6,252	137,418	6,902	3,790,350	**3,940,922**
2027	5,113	126,742	6,363	3,797,399	**3,935,617**
2028	4,075	116,801	5,860	3,801,270	**3,928,005**
2029	3,282	107,837	5,408	3,812,482	**3,929,009**
2030	2,461	99,567	4,991	3,823,520	**3,930,539**
2031	1,440	91,844	4,599	3,829,785	**3,927,668**
2032	635	84,648	4,236	3,833,094	**3,922,613**
2033	69	78,056	3,903	3,838,933	**3,920,961**
2034	(523)	72,034	3,599	3,847,245	**3,922,355**
2035	(779)	66,297	3,311	3,846,470	**3,915,299**

Step 3: Adoption Curves

Using Ontario market adoption equation with LDC specific historic program participation, the LDC specific adoption curves are developed. The annual incremental adoption rates are used in the model.

Example LDC incremental adoption rates:

Utility Adoption Curves

	6	7	8	9	10	11	12	13	14	15
	AchExisting_ECM	AchExisting_CACI	AchExistin_CACI	AchExisting_ECM	AchExisting_air dr	AchExisting_cfl	AchExisting_dhw	AchExisting_fans	AchExisting_fix	AchExisting_led
2015	1.18%	0.21%	0.77%	0.53%	0.18%	2.67%	0.05%	0.11%	0.3[illegible]	0.62%
2016	1.21%	0.21%	0.76%	0.73%	0.16%	2.97%	0.04%	0.10%	0.39%	0.77%
2017	1.17%	0.20%	0.72%	1.36%	0.11%	3.33%	0.03%	0.07%	0.53%	0.93%
2018	0.90%	0.17%	0.55%	1.61%	0.06%	3.48%	0.02%	0.04%	0.59%	1.10%
2019	0.61%	0.13%	0.38%	1.75%	0.03%	3.51%	0.01%	0.02%	0.65%	1.29%
2020	0.38%	0.09%	0.24%	1.69%	0.01%	3.41%	0.00%	0.01%	0.68%	1.46%

Step 4: Measure Mapping Parameters

Measure research defines parameters (savings, cost and measure life). Measure permutations are mapped to subsector, end use and equipment type. This results in the development of competition groups. Measures are also mapped to adoption curves and archetype programs.

Example of LDC measure mapping parameters:

Name	Baseline Description	Vintage	Segment	Climat	End Use	Equip Type/Competition Grou	Adoption Curve AchBase	Baseline kWh	Measure kWh	Savings kWh	Energy Savings
ENERGY STAR LED 7W	EISA Compliant 43W Halogen Bulb	Turnover	Single Family	Zone 7	Lighting	Screw-in Lamps	AchExisting_led	55	9	46	83.7%
ENERGY STAR LED 7W	EISA Compliant 43W Halogen Bulb	Turnover	Row House	Zone 7	Lighting	Screw-in Lamps	AchExisting_led	55	9	46	83.7%
ENERGY STAR LED 7W	EISA Compliant 43W Halogen Bulb	Turnover	MURB Low Rise	Zone 7	Lighting	Screw-in Lamps	AchExisting_led	55	9	46	83.7%
ENERGY STAR LED 7W	EISA Compliant 43W Halogen Bulb	Turnover	MURB High Rise	Zone 7	Lighting	Screw-in Lamps	AchExisting_led	55	9	46	83.7%
ENERGY STAR LED 7W	EISA Compliant 43W Halogen Bulb	Turnover	Other Residential Builc	Zone 7	Lighting	Screw-in Lamps	AchExisting_led	55	9	46	83.7%
ENERGY STAR LED 7W	EISA Compliant 43W Halogen Bulb	Turnover	Single Family	Zone 7	Lighting	Lighting Common Areas (MR)	AchExisting_led	55	9	46	83.7%
ENERGY STAR LED 7W	EISA Compliant 43W Halogen Bulb	Turnover	Row House	Zone 7	Lighting	Lighting Common Areas (MR)	AchExisting_led	55	9	46	83.7%
ENERGY STAR LED 7W	EISA Compliant 43W Halogen Bulb	Turnover	MURB Low Rise	Zone 7	Lighting	Lighting Common Areas (MR)	AchExisting_led	55	9	46	83.7%
ENERGY STAR LED 7W	EISA Compliant 43W Halogen Bulb	Turnover	MURB High Rise	Zone 7	Lighting	Lighting Common Areas (MR)	AchExisting_led	55	9	46	83.7%
ENERGY STAR LED 7W	EISA Compliant 43W Halogen Bulb	Turnover	Other Residential Builc	Zone 7	Lighting	Lighting Common Areas (MR)	AchExisting_led	55	9	46	83.7%
ENERGY STAR LEDL 12W	EISA Compliant 53W Halogen Bulb	Turnover	Single Family	Zone 7	Lighting	Screw-in Lamps	AchExisting_led	68	15	52	77.4%
ENERGY STAR LEDL 12W	EISA Compliant 53W Halogen Bulb	Turnover	Row House	Zone 7	Lighting	Screw-in Lamps	AchExisting_led	68	15	52	77.4%
ENERGY STAR LEDL 12W	EISA Compliant 53W Halogen Bulb	Turnover	MURB Low Rise	Zone 7	Lighting	Screw-in Lamps	AchExisting_led	68	15	52	77.4%
ENERGY STAR LEDL 12W	EISA Compliant 53W Halogen Bulb	Turnover	MURB High Rise	Zone 7	Lighting	Screw-in Lamps	AchExisting_led	68	15	52	77.4%
ENERGY STAR LEDL 12W	EISA Compliant 53W Halogen Bulb	Turnover	Other Residential Builc	Zone 7	Lighting	Screw-in Lamps	AchExisting_led	68	15	52	77.4%
ENERGY STAR LEDL 12W	EISA Compliant 53W Halogen Bulb	Turnover	Single Family	Zone 7	Lighting	Lighting Common Areas (MR)	AchExisting_led	68	15	52	77.4%
ENERGY STAR LEDL 12W	EISA Compliant 53W Halogen Bulb	Turnover	Row House	Zone 7	Lighting	Lighting Common Areas (MR)	AchExisting_led	68	15	52	77.4%
ENERGY STAR LEDL 12W	EISA Compliant 53W Halogen Bulb	Turnover	MURB Low Rise	Zone 7	Lighting	Lighting Common Areas (MR)	AchExisting_led	68	15	52	77.4%
ENERGY STAR LEDL 12W	EISA Compliant 53W Halogen Bulb	Turnover	MURB High Rise	Zone 7	Lighting	Lighting Common Areas (MR)	AchExisting_led	68	15	52	77.4%
ENERGY STAR LEDL 12W	EISA Compliant 53W Halogen Bulb	Turnover	Other Residential Builc	Zone 7	Lighting	Lighting Common Areas (MR)	AchExisting_led	68	15	52	77.4%

Step 5: Ranking of Measures by TRC

Measure in each vintage competition group ranked according to TRC.

Example of LDC ranking of measures:

Turnover

Measure Number	Measure Code	Name	Measure Type	Equip Type/Competition Group	B/C Ratio	Applicability	Energy Savings % Lookup	Equip Rank	Nonequip Rank	Overall Rank	Equip Measure Count
1	ET917	ENERGY STAR LED 25W	Equip	Screw-in Lamps	5.77	5.9%	75.0%	1		1	27
2	ET767	Energy Star Torchiere	Equip	Screw-in Lamps	5.41	[illegible]	[illegible]	2		2	
3	ET887	ENERGY STAR LED 18W	Equip	Screw-in Lamps	4.77	5.9%	75.0%	3		3	
4	ET1067	ENERGY STAR CFL 20W	Equip	Screw-in Lamps	4.22	5.9%	62.3%	4		4	
5	ET857	ENERGY STAR LEDL 12W	Equip	Screw-in Lamps	4.16	5.9%	77.4%	5		5	
6	ET827	ENERGY STAR LED 7W	Equip	Screw-in Lamps	3.80	5.9%	83.7%	6		6	
7	ET977	ENERGY STAR CFL 15W	Equip	Screw-in Lamps	3.59	5.9%	65.1%	7		7	
8	ET662	ENERGY STAR QUALIFIED RECESSED LIGHTING	Equip	Screw-in Lamps	3.51	29.5%	82.1%	8		8	
9	ET1037	ENERGY STAR CFL 40W	Equip	Screw-in Lamps	3.46	5.9%	60.0%	9		9	
10	ET437	ENERGY STAR® QUALIFIED SPECIALTY COMPA	Equip	Screw-in Lamps	3.25	23.6%	71.1%	10		10	
11	ET482	ENERGY STAR® QUALIFIED SPECIALTY COMPA	Equip	Screw-in Lamps	3.21	58.9%	78.0%	11		11	
12	ET947	ENERGY STAR CFL 10W	Equip	Screw-in Lamps	3.19	5.9%	65.5%	12		12	
13	ET512	ENERGY STAR® QUALIFIED SPECIALTY COMPA	Equip	Screw-in Lamps	3.13	58.9%	74.7%	13		13	
14	ET1007	ENERGY STAR CFL 25W	Equip	Screw-in Lamps	2.87	5.9%	65.3%	14		14	
15	ET797	ENERGY STAR LED 5W	Equip	Screw-in Lamps	2.81	5.9%	82.8%	15		15	
16	ET332	ENERGY STAR® QUALIFIED SPECIALTY COMPA	Equip	Screw-in Lamps	2.74	23.6%	55.8%	16		16	
17	ET572	ENERGY STAR® QUALIFIED COMPACT FLUORE	Equip	Screw-in Lamps	2.29	5.9%	69.8%	17		17	
18	ET692	ENERGY STAR QUALIFIED RECESSED LIGHTING	Equip	Screw-in Lamps	2.06	29.5%	56.6%	18		18	
19	ET392	ENERGY STAR® QUALIFIED COMPACT FLUORE	Equip	Screw-in Lamps	1.80	29.5%	75.9%	19		19	
20	ET242	ENERGY STAR® QUALIFIED LED BULBS - Specia	Equip	Screw-in Lamps	1.71	29.5%	86.7%	20		20	
21	ET542	ENERGY STAR® QUALIFIED COMPACT FLUORE	Equip	Screw-in Lamps	1.55	58.9%	59.5%	21		21	
22	ET422	ENERGY STAR® QUALIFIED SPECIALTY COMPA	Equip	Screw-in Lamps	1.53	29.5%	75.0%	22		22	
23	ET632	ENERGY STAR QUALIFIED LIGHT FIXTURE - 3 C	Equip	Screw-in Lamps	1.47	30.4%	64.3%	23		23	
24	ET602	ENERGY STAR QUALIFIED LIGHT FIXTURE - 1 C	Equip	Screw-in Lamps	1.46	30.4%	64.0%	24		24	
25	ET362	ENERGY STAR® QUALIFIED SPECIALTY COMPA	Equip	Screw-in Lamps	1.12	58.9%	80.0%	25		25	
26	ET302	ENERGY STAR® QUALIFIED LED BULBS - Specia	Equip	Screw-in Lamps	1.09	23.6%	80.8%	26		26	
27	ET272	ENERGY STAR® QUALIFIED LED BULBS - Specia	Equip	Screw-in Lamps	1.00	29.5%	82.5%	27		27	
28											
29											
30											

Step 6: Calculate Savings

In each vintage group, calculates savings for first ranked TRC. Remove this savings from available load for next measure in TRC ranking, to calculate savings for the next measure.

The following equation is used to calculate the savings:

Annual Savings per Measure (kWh/year) =

= (kWh Load share) x (% Incremental adoption rate) x (% Measure applicability) x (% Savings of measure)

Using the values as indicated in this example the achievable potential savings for the LED measures is calculated:

= (414,786 kWh) x (0.62%) x (5.9%) x (75.0%) = 114 kWh/year

Example of LDC measure savings calculation in model:

1	Measure Code	Description	Type	Measure Life
(Overall rank)	ET917	ENERGY STAR LED 25W	Equip	20
Competition Group	Applicability	Adoption Curve	Energy Savings %	Demand-to-Energy Ratio
Screw-in Lamps	5.9%	AchExisting_led	75.0%	0.0%
These tables apply measure-level savings for each measure in the table above.				

	Annual Energy Savings	Cumulative Energy Saving
2015	114	114
2016	112	226
2017	123	349
2018	133	482
2019	143	625
2020	148	773

Nexant, Inc.

Nexant Canada, Inc.

TD Canada Trust Tower

161 Bay Street, 27th Floor

M5J 2S1 Toronto

Canada

www.nexant.com