2019 Integrated Ontario Electricity and Natural Gas Achievable Potential Study

Prepared for

ieso
Connecting Today.
Powering Tomorrow.

ONTARIO
ENERGY
BOARD

Submitted: 2019-09-13
Updated: 2019-12-10

Prepared by:

Navigant
100 King Street West | Suite 4950
Toronto, ON M5X 1B1

416.777.2440
navigant.com

NAVIGANT

VERSION TRACKING

Submission Date	Change Log
2019-09-13	First published version.
2019-12-10	1. Footnote 3 updated. Citation updated, now references April 2019 *Cost-Effectiveness Guide*. 2. Footnote 30 updated. Citation updated, now references October 2019 version of IESO’s cost-effectiveness tool. 3. Footnote 31 updated. Citation updated, now references April 2019 version of IESO’s EM&V Protocols

EXECUTIVE SUMMARY

In 2018, Navigant Consulting, Ltd. (Navigant) was engaged by the Independent Electricity System Operator (IESO) and the Ontario Energy Board (OEB) to prepare an integrated energy efficiency achievable potential study (APS) for electricity and natural gas across Ontario over a 20-year period, from 2019 to 2038.

Background and Objectives

The main objective of the APS is to identify and quantify achievable potential energy savings (electricity and natural gas) and greenhouse gas (GHG) emissions reductions, and the costs associated with delivering this potential for the period of 2019-2038. The APS will provide data and analysis to inform:

- The development of future conservation policy or frameworks
- Program design, implementation and evaluations
- Long-term resource planning and system operations

In previous cycles, the IESO and the OEB commissioned separate studies of electricity and natural gas potential in the province. This 2019 study differs from previous studies in that it covers both electricity and natural gas in a single modelling effort, delivering an integrated analysis of electricity and natural gas energy efficiency potential.

Scope and Methodology

To quantify the achievable potential savings, and the associated program costs and provincial GHG reductions Navigant completed the following tasks.

- **Base Year Disaggregation.** This task uses recent historical data to develop the approaches required to disaggregate the reference forecasts into the required geographic, segment-level[1] and end-use granularity. The base year data (consumption, etc.) used to accomplish this task was 2017, the most recent full calendar year for which historical data were available.
- **Reference Forecast.** This task uses the IESO and natural gas utilities' forecasts of energy consumption, and the outputs of the base year disaggregation to develop a combined reference forecast of energy consumption in the province that aligns with the granularity established for this study as part of the base year disaggregation.
- **Measure Characterization.** This task defines, based on the best available data, the characteristics of energy efficiency and fuel switching measures considered by the study, such as measure savings, costs, baselines, and existing market share (saturation).
- **Technical Potential.** This task estimates the hypothetical energy efficiency potential under the assumption that all baseline technologies are replaced by the energy efficient measures that deliver the most savings, as soon as possible, where it is technically feasible to do so..

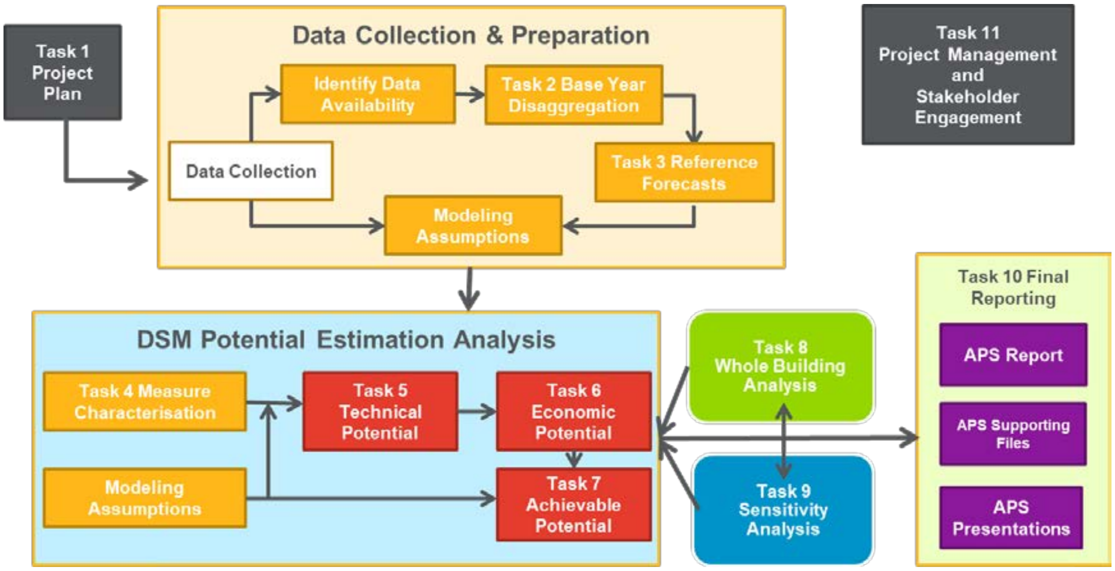
---

[1] A "segment" is a sub-grouping of a sector, sometimes referred to in other studies as a sub-sector. For example, hospitals are a segment of the commercial sector.

- **Economic Potential.** This task estimates the hypothetical energy efficiency potential under the assumption that all baseline technologies are replaced by the *cost-effective* energy efficient measures that deliver the most savings, as soon as possible, where technically feasible.
- **Achievable Potential.** This task estimates the energy efficiency potential under a number of different scenarios, accounting for realistic market adoption rates that consider consumer behaviour and decision-making and quantify the costs of delivering this potential.
- **Whole Building Analysis.** The goal of this task is to develop, for a single commercial segment, a “top-down” econometric forecast of energy efficiency potential to compare to the more traditional “bottom-up” measure-based modelling outputs. The purpose of this task is to identify opportunities to use actual historical building-level consumption data to inform achievable potential modelling in the future.
- **Sensitivity Analysis.** This task quantifies the approximate uncertainty associated with estimated potential by testing the sensitivity of outputs to changes in key modelling parameters.

A diagram of the overall study process, including the relationships between the various tasks, and the timing of their completion is summarised in Figure ES-1.

Figure ES-1. Overview of Study Process



Source: Navigant analysis

Achievable Potential Scenarios

Achievable potential is the subset of savings potential that is technically feasible, cost effective and also considers the impact of consumer behaviour on measure adoption. Specifically, achievable potential estimates market adoption by considering how customers may respond to different incentive scenarios given their payback acceptance thresholds as well as their awareness of and ability to acquire measures.

Navigant has estimated four sets of achievable potential results, corresponding to four different scenarios of incentive spending and assumed quality of program design. The four scenarios are summarised in Table ES-1.

Table ES-1. Achievable Potential Scenarios

Scenario	Electricity Constraint	Natural Gas Constraint
Unconstrained Potential (scenario B)	• Incentives set at 100% of incremental cost of each measure. • Assumes idealized program design (i.e., fewer market barriers and higher adoption rates)	• Incentives set at 100% of incremental cost of each measure. • Assumes idealized program design (i.e., fewer market barriers and higher adoption rates)
Semi-Constrained Potential (scenario C)	• Incentives set such that average incentive payment is ~2.5 cents/kWh of lifetime energy savings for individual measures. • Assumes standard adoption rates	• Deliver 415 Mm^3 per year, incremental to Scenario A by 2030 • Assumes standard adoption rates
Constrained Potential (Scenario A)	• Incentives capped at 2.5 cents/kWh of lifetime energy savings for individual measures. • Assumes standard adoption rates	• Program costs capped at $80M/year (annually for first five years and averaged over last 15 years). • Assumes standard adoption rates
Demand-Targeted Potential (Scenario D – electricity only)	• Measure incentive capped at $123/kW-year of lifetime summer peak demand savings for individual measures. • Assumes standard adoption rates	• Not applicable

Source: Navigant analysis

Forecast Potential Results

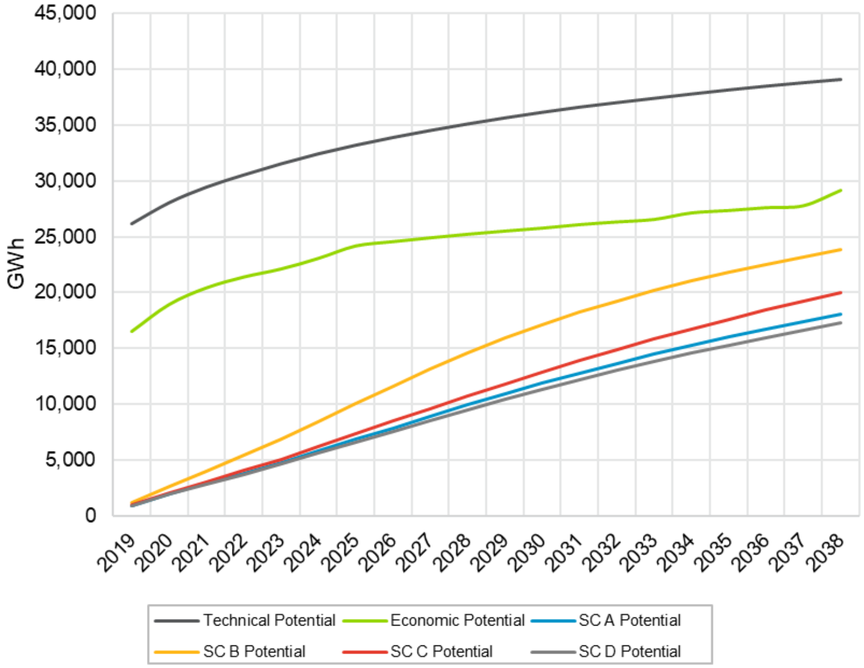
This section provides a summary of the forecast potential savings, avoided GHG emissions, and program costs.

Persistent Annual Potential Energy Savings, GHG Reductions, and Program Costs

Figure ES-2 shows the estimated annual savings potential associated with the cumulative adoption of measures over time (e.g., savings in 2020 represent the potential savings in 2020 of measures adopted in 2019 and 2020) for the screens and scenarios modeled.

The technical and economic potential is very high starting in the first year of the study because the immediate adoption of all retrofit measures is assumed. In contrast, adoption in the achievable potential scenarios reflects parameters that model consumer behaviour, resulting in a more gradual adoption. By the end of the study period, the achievable potential scenarios estimate between 18 and 24 TWh of potential electric energy savings being available.

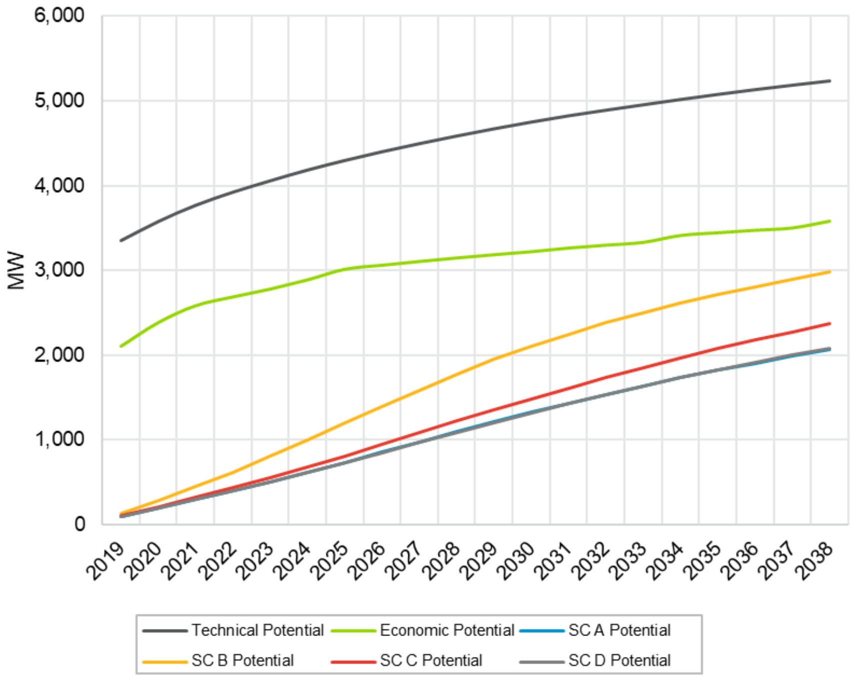
Figure ES-2. Electric Energy Potential



Source: Navigant analysis

Figure ES-3 shows the provincial electric summer peak demand potential associated with the cumulative adoption of measures over time (e.g., savings in 2020 represent the potential savings in 2020 of measures adopted in 2019 and 2020). Peak demand savings potential reflects the amount of electricity demand reduction that happens during the time when the demands on the electricity system are the highest during the summer period. Targeting electricity energy efficiency measures that deliver savings during this peak period helps ensure measures are delivering the greatest benefit at the time when the system needs it most. By the end of the study period, the achievable potential scenarios estimate between 2,000 and 3,000 MW of potential peak electricity demand savings are available.

Figure ES-3. Electric Summer Peak Demand Potential



Source: Navigant analysis

The potential values above as well as other key summary statistics associated with the potential estimation are provided in Table ES-2.

Table ES-2. Key Electricity Potential Summary Statistics – Three Indicative Years

Year	Potential Type	Energy Potential (GWh)	Summer Peak Demand Potential (MW)	GHG Emissions Reduction (KT CO2e)	Program Cost in Given Year ($ Million)	Average Incentive LUEC ($/lifetime kWh)	TRC-Plus[2] Ratio	PAC Ratio[3]
2023	Max Achievable (Sc B)	6,914	802	345	$506	$0.027	3.3	1.6
2030	Max Achievable (Sc B)	17,132	2,104	1,004	$504	$0.033	3.2	1.8
2038	Max Achievable (Sc B)	23,846	2,980	1,773	$365	$0.039	2.9	1.8
2023	Semi Constrained (Sc C)	5,110	549	255	$355	$0.024	3.3	1.9

---

[2] TRC stands for “Total Resource Cost”, a cost-effectiveness metric that compares the full incremental cost of an energy efficiency measure with the avoided supply-side costs. “TRC-plus” refers to the version of this cost-effectiveness that includes a 15% benefits adder to account for non-energy impacts. For more information, please refer to Chapter 6.

[3] PAC stands for “Program Administrator Cost”, a cost-effectiveness metric that compares measure incentives plus program administration costs with avoided resource costs. PAC was not used for cost-effectiveness screening in this study but has been produced as an output of the DSMSim model. More details on cost-effectiveness tests may be found in:

Independent Electricity System Operator, *Conservation & Demand Management Efficiency Cost Effectiveness Guide,* April 2019 http://www.ieso.ca/-/media/Files/IESO/Document-Library/conservation/EMV/2019/IESO-CDM-Cost-Effectiveness-Test-Guide.pdf?la=en

Year	Potential Type	Energy Potential (GWh)	Summer Peak Demand Potential (MW)	GHG Emissions Reduction (KT CO2e)	Program Cost in Given Year ($ Million)	Average Incentive LUEC ($/lifetime kWh)	TRC-Plus[2] Ratio	PAC Ratio[3]
2030	Semi Constrained (SC C)	12,918	1,484	757	$433	$0.030	3.5	2.2
2038	Semi Constrained (Sc C)	19,975	2,368	1,485	$383	$0.036	3.4	2.5
2023	Constrained (Sc A)	4,830	503	241	$231	$0.015	3.7	2.8
2030	Constrained (Sc A)	11,893	1,324	697	$274	$0.019	4.0	3.5
2038	Constrained (Sc A)	18,074	2,061	1,344	$189	$0.018	4.0	5.1

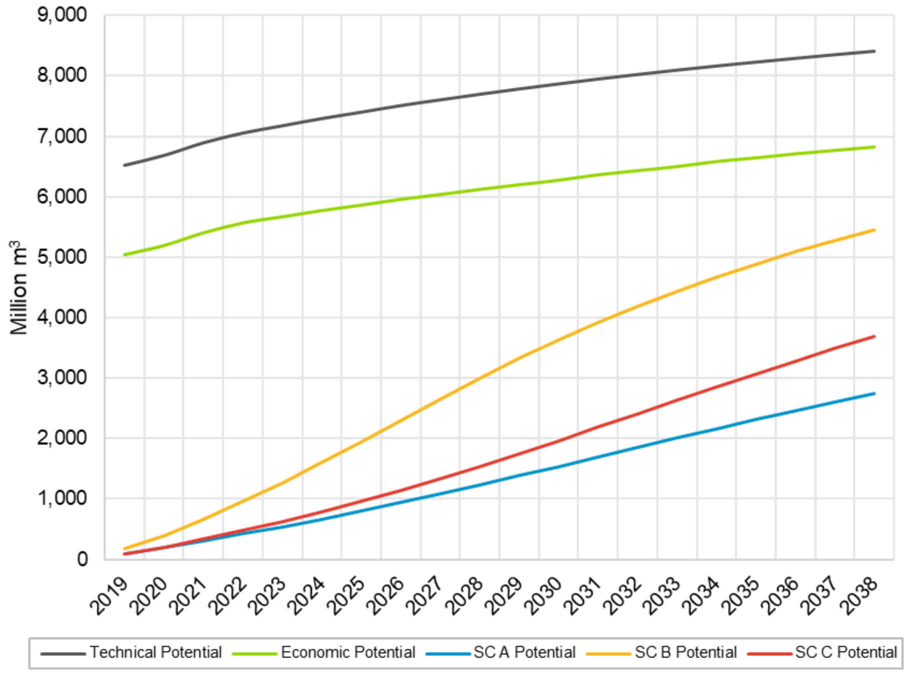
Year	Potential Type	Energy Potential (GWh)	Summer Peak Demand Potential (MW)	GHG Emissions Reduction (KT CO2e)	Program Cost in Given Year ($ Million)	Average Incentive LUEC ($/lifetime kW)	TRC-Plus Ratio	PAC Ratio
2023	Demand Targeted (Sc D)	4,650	500	232	$80	$90.82	3.6	3.0
2030	Demand Targeted (Sc D)	11,334	1,316	664	$252	$112.84	3.8	3.0
2038	Demand Targeted (Sc D)	17,266	2,078	1,284	$204	$103.57	3.6	4.0

Source: Navigant analysis

The potential energy and summer peak demand savings, as well as associated GHG emissions reductions, reflect the annual savings potential associated with the cumulative measure adoption through to the end of that year. The program cost (i.e. the sum of incentive and administrative costs) and the LUEC (i.e. total program costs divided by the lifetime savings of measures adopted in that year) are provided only for measures installed within the given year – this provides an indication of how annual costs and LUECs compare across scenarios and how they change overtime.

Figure ES-4 shows the provincial natural gas potential of the entire portfolio over time, by potential type and scenario. The potential shown in this figure is the estimated annual savings potential associated with the cumulative adoption of measures over time (e.g., savings in 2020 represent the potential savings in 2020 of measures adopted in 2019 and 2020).

Figure ES-4. Natural Gas Potential



Source: Navigant analysis

The potential values above as well as other key summary statistics associated with the potential estimation are provided in Table ES-3.

Table ES-3. Key Natural Gas Potential Summary Statistics – Three Indicative Years

Year	Potential Type	Natural Gas Potential (Million m3)	GHG Emissions Reduction (KT CO2e)	Program Admin Cost in Given Year ($ Million)	Average Incentive LUEC ($/lifetime m3)	TRC-Plus[4] Ratio	PAC Ratio[5]
2023	Max Achievable (Sc B)	1,266	2,474	$548	$0.082	3.3	1.6
2030	Max Achievable (Sc B)	3,634	7,106	$749	$0.104	3.2	1.8
2038	Max Achievable (Sc B)	5,458	10,672	$665	$0.131	2.9	1.8
2023	Semi Constrained (Sc C)	623	1,217	$175	$0.054	3.3	1.9
2030	Semi Constrained (SC C)	1,969	3,849	$309	$0.063	3.5	2.2
2038	Semi Constrained (Sc C)	3,687	7,209	$363	$0.074	3.4	2.5
2023	Constrained (Sc A)	542	1,060	$79	$0.031	3.7	2.8
2030	Constrained (Sc A)	1,542	3,014	$79	$0.024	4.0	3.5
2038	Constrained (Sc A)	2,740	5,357	$79	$0.021	4.0	5.1

Source: Navigant analysis

---

[4] See above for definition and description.

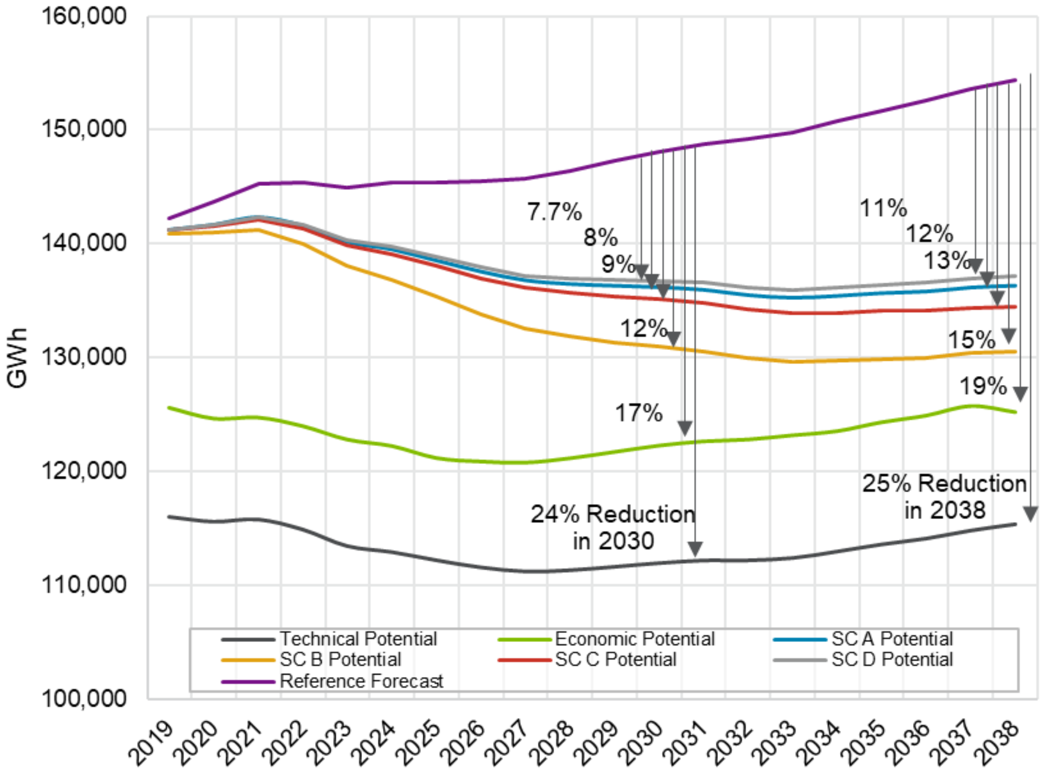
[5] See above for definition and description.

Comparison of Potential Energy Savings with Reference Forecast

Figure ES-5 shows the provincial electric energy reference forecast across the reference forecast period. This figure also shows how that reference forecast changes when forecast potential is subtracted for it. The potential values in the figure below are identical to those shown in the sub-section above.

Growth in the electricity reference forecast is driven in large part by growth in commercial sector consumption (14% between 2019 and the end of 2038). Growth in the residential and industrial sectors' reference forecast in the same period is 5% and 7%, respectively. Reductions in the reference forecast consumption by potential type and scenario reflect the potential values shown in the graphs above.

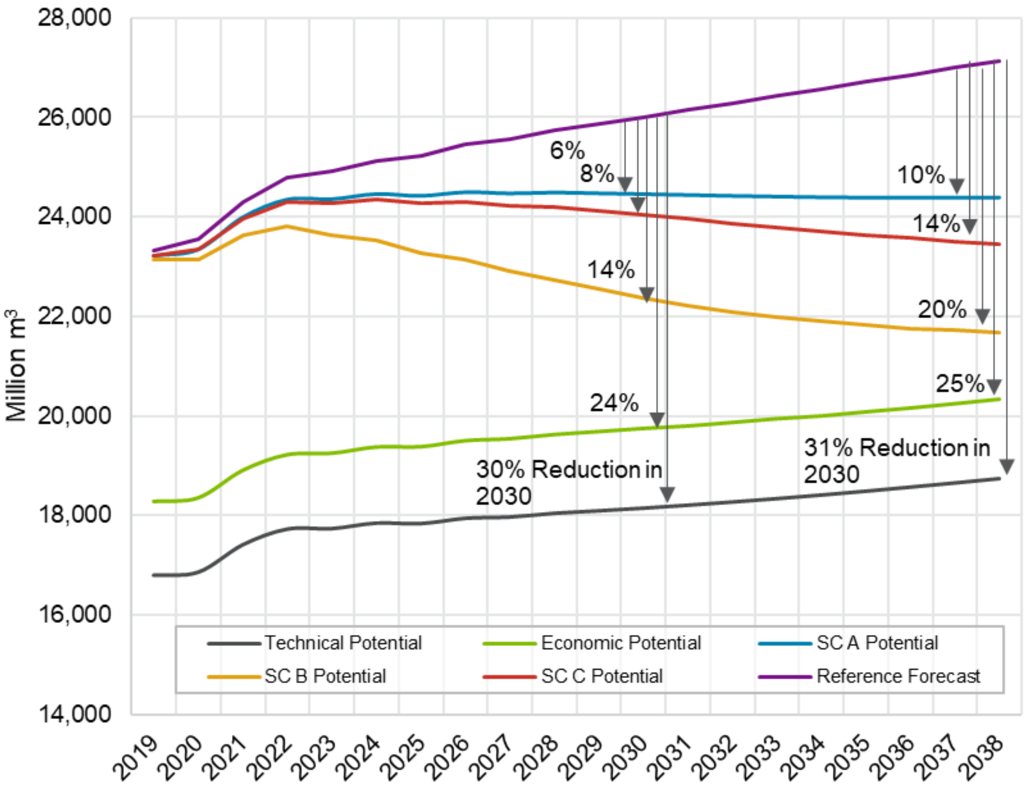
Figure ES-5. Electric Energy Potential – Compared with Reference Forecast



Source: Navigant analysis

Growth in the natural gas reference forecast is driven predominantly by growth in industrial sector consumption (27% between 2019 and the end of 2038). Growth in the residential and commercial sectors' reference forecast in the same period is 9% and 11%, respectively.

Figure ES-6. Natural Gas Potential – Compared with Reference Forecast



Source: Navigant analysis

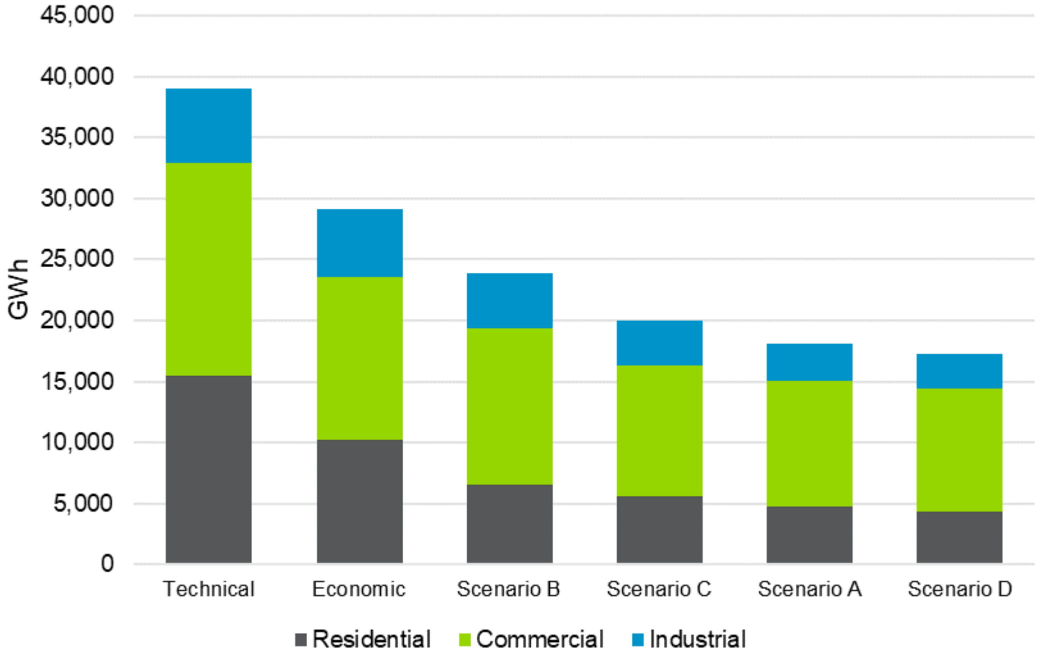
Comparison of Potential Across Sectors and Scenarios

This section provides a summary of the potential savings opportunities in each sector.

Electricity Potential by Sector

Figure ES-7 shows the total achievable annual electric energy savings potential in 2038 for all measures installed over the potential reference forecast period broken down by sector and scenario. By 2038, Scenarios B, C, A, and D reach 82%, 69%, 62%, and 59% of the economic potential, respectively.

Figure ES-7. Electric Energy Achievable Savings Potential by Sector and Scenario in 2038 (GWh)



Source: Navigant analysis

In all years of the reference forecast period, the commercial sector contributes significantly to portfolio electric energy potential: although it accounts for just over a third of the 2038 consumption in the reference forecast, this sector delivers between 54% and 59% of electric energy achievable potential (depending on the scenario).

One important factor that is driving this result is the avoided electricity system costs used for this study, which have decreased in recent years. Avoided costs are used in the economic potential screen to select measures that are cost-effective from a system perspective. As avoided costs decrease to reflect the relatively low marginal cost of electric energy and capacity in Ontario, measures that are deemed cost effective from a system perspective will have lower incremental costs and will therefore be generally more cost effective from the customer's perspective. At a measure level, the effect is that low-cost commercial lighting and whole-building measures tend to make up a large portion of achievable potential across all scenarios. From a program perspective, incentives alone become less effective at motivating measure adoption, and achieving material amounts of incremental potential may require non-incentive programmatic intervention to increase measure awareness and remove any market barriers.

Residential

Year	2023	Percent of total sectoral energy savings	2038	Percent of total sectoral energy savings
Top Segments	Single Family Detached Home	46%	Single Family Detached Home	45%
	Low Income Multi-Family	13%	High Rise Multi-Family	13%
Top End Uses	Lighting	52%	Lighting	32%
	Washing/Drying Appliances	14%	Space Cooling	16%
Top Measures	ENERGY STAR LED Specialty Bulbs	31%	ENERGY STAR Clothes Washer	12%
	ENERGY STAR Clothes Washer	12%	ENERGY STAR LED Specialty Bulbs	11%
	LED MR/PAR Lamps	9%	Ductless Mini-Split Heat Pumps	8%

In 2023, the residential sector accounts for approximately a quarter of the total electric energy savings that year and essentially maintains its position in 2038 with 28% of the total electric energy savings.

Top Residential Segments

The single family detached home segment accounts for the largest proportion of potential; this segment also accounts for the largest proportion of forecast consumption (just under half of residential consumption in both 2023 and 2038).

While comprising a relatively small share of total potential, the low income multi-family and multi-family high rises segments provide a disproportionately large contribution to total potential compared to their share of the reference forecast. The forecast 2038 consumption of these two segments is approximately 18% of total consumption but contribute 26% of sectoral energy efficiency potential. This disproportionate contribution to potential is driven by the opportunities in whole building and common space measures – for example, the measure contributing the ninth highest potential in 2038 is building recommissioning.

Top Residential End Uses

Lighting is the biggest source of residential potential, despite increasing codes and standards requirements and anticipated natural conservation, delivering more than half of the total potential in this sector. Over time, however, potential in other end-uses is expected to grow faster than lighting – for example, space heating and space cooling together account for 20% of potential in 2023, but 30% by 2038. This pattern is also evident when the measure-level savings are considered. In 2023, two of the top three highest potential residential measures (contributing 40% of total potential) are lighting measures. In contrast, by 2038 only one of the top three measures is lighting related.

Top Residential Measures

When contributions to summer peak demand potential are considered, the composition of the top contributing measures changes significantly. Only one of the top 10 contributors to 2038 summer peak demand savings is an LED bulb, whereas seven of the top 10 contributors to peak demand savings are measures related to space cooling and ventilation, in particular ductless mini-split heat pumps account for 17% of summer peak demand savings, and adaptive thermostats account for approximately 10% of summer peak demand savings.

Commercial

Year	2023	Percent of total sectoral energy savings	2038	Percent of total sectoral energy savings
Top Segments	Other Office	15%	Other Office	15%
	Other Non-Food Retail	12%	Other Non-Food Retail	12%
Top End Uses	Lighting	71%	Lighting	57%
	All (Multiple End Uses)	7%	All (Multiple End Uses)	11%
Top Measures	ENERGY STAR LED Reflector Lamps	16%	LED High/Low Bay Fixtures	11%
	LED Exterior Area Lights	10%	LED Troffers and Suspended Fixtures	10%

In 2023, the commercial sector accounts for almost two-thirds of the total electric energy savings that year decreasing as a proportion of the total to contribute approximately 56% of the total electric energy savings in 2038.

Top Commercial Segments

Contributions to potential by segment are approximately proportional to segment consumption with the other office (all offices less than 20,000 square feet in size) segment contributing the most potential. This segment accounts for 20% of forecast commercial electricity consumption in 2038.

The distribution of commercial potential across segments does not change significantly over time, and is reasonably consistent with the distribution of forecast consumption: the other office segment, forecast to make the most significant contribution to consumption in 2038 (19% of total commercial consumption) is also the one predicted by the study to offer the most energy efficiency potential.

Top Commercial End Uses

The lighting end use dominates the commercial sector, as shown in the table above. Although lighting's contribution to achievable potential falls from 71% (in 2023) to 57% (in 2038) of sectoral potential, it still accounts for more than half the electricity potential in the commercial sector in the terminal year. The two reasons this end use dominates the potential in this sector are the very low cost of the measures (many LED lighting measures become, over the course of the study, less costly than the associated baseline measure), and the forecasted natural conservation for this end use is low. The two most significant non-lighting end-uses in this sector are: the "All (Multiple End Uses)" end-use (building automation, recommissioning, etc.) and the refrigeration end-use, which together account for approximately 21% of commercial electric potential by 2038.

Top Commercial Measures

Of the 10 measures contributing most to the 2038 energy potential for this sector, seven are lighting measures. Of the remaining three of the top 10 measures, two are retrofits (recommissioning and furnace tune-ups), and only one is an equipment replacement (high efficiency air source heat pump).

When contributions to summer peak demand potential are considered, the distribution changes somewhat: although the top three contributors to potential remain lighting measures, the HE air source heat pump climbs the list to the fifth highest contributor, and three lighting measures are replaced in the top 10 contributors by: unitary air conditioning units, education and capacity building, and refrigerated display case doors.

Industrial

Year	2023	Percent of total sectoral energy savings	2038	Percent of total sectoral energy savings
Top Segments	Mining, Quarrying and Oil & Gas Extraction	21%	Mining, Quarrying and Oil & Gas Extraction	17%
	Agriculture	15%	Other Industrial	13%
Top End Uses	Compressed Air	36%	Motors - Pumps	31%
	Motors - Pumps	29%	Compressed Air	31%
Top Measures	Air Compressor Optimization	20%	Pump System Optimization	20%
	Pump System Optimization	18%	Air Compressor Optimization	12%

In 2023, the industrial sector accounts for 12% of the total electric energy savings that year increasing as a proportion of the total to contribute approximately 19% of the total electric energy savings in 2038.

Top Industrial Segments

The most significant change in the distribution of industrial potential by segment across time is the shift in the contribution of the agriculture sector and in the mining quarrying and oil and gas extraction segment. Combined, these sectors contribute approximately 30% of potential in 2038, but approximately 36% in 2023.

Top Industrial End Uses

Compressed air and motors – pumps have the greatest potential together accounting for nearly two thirds of total industrial potential in 2038. The remainder of the electric energy potential is dominated by the “All (Multiple End Uses)” category. Altogether, in 2038, only 20% of the industrial potential does not fall in one of those three end use categories.

Top Industrial Measures

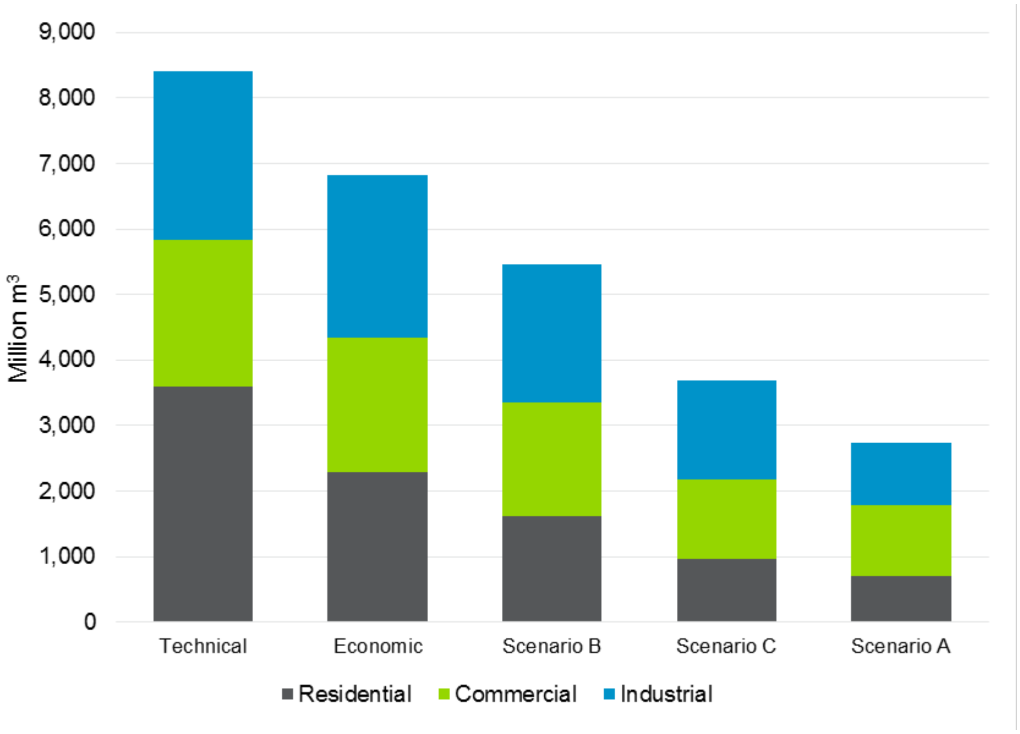
As would be expected, given the end use potential, compressed air and motors - pumps measures dominate the list of measures that contribute to most potential. The top five measures include two pump motor measures (pump system optimisation, and pump equipment upgrade), two compressed air measures (aid compressor optimisation and air leak survey), and one all (multiple end uses measure (recommissioning).

The top 10 measures contributing to summer peak demand potential are nearly the same as those contributing to energy potential (expected, given industrial load shapes), with the only change in the top 10 contributors, being the replacement of greenhouse grow lights (tenth highest contribution to energy potential) by fan system optimisation.

Natural Gas Potential by Sector

Figure ES-8 shows the total natural gas energy achievable savings potential for each sector and scenario in 2038. By 2038, Scenarios B, C, and A reach 80%, 54%, and 40% of the economic potential, respectively.

Figure ES-8. Natural Gas Energy Achievable Savings Potential by Sector and Scenario in 2038 (Million m^3)



Source: Navigant analysis

Within Scenarios B and C, the industrial sector is the greatest contributor to provincial potential and is responsible for approximately 40% of the total potential. This is proportional to the industrial sector's contribution to forecast natural gas consumption – the industrial sector is forecast to account for approximately 42% of provincial natural gas consumption in 2038.

In Scenario A, however, when the program costs are constrained, the commercial sector overtakes the industrial sector as the greatest contributor to provincial potential providing 39% of the total potential. This change is due to the incentives applied being much lower and prioritized to the most cost-effective measure. Given the high cost of industrial equipment and steep payback acceptance curve for the sector, reducing incentives significantly reduces the industrial potential.

Residential

	2023	Percent of total sectoral energy savings	2038	Percent of total sectoral energy savings
Top Segments	Single Family Detached Home	45%	Single Family Detached Home	43%
	High Rise Multi-Family	21%	High Rise Multi-Family	21%
Top End Uses	Space Heating	87%	Space Heating	86%
	All (Multiple End Uses)	13%	All (Multiple End Uses)	13%
Top Measures	Adaptive Thermostat	18%	Adaptive Thermostat	17%
	Comprehensive Draft Proofing	17%	Comprehensive Draft Proofing	15%

Top Residential Segments

The distribution of projected potential across segments is similar to that observed for electricity: single family detached homes deliver the highest proportion of savings (expected, given that this segment accounts for the highest proportion of consumption), and the low-income multi-family and high rise multi-family segments contribute disproportionately to potential, given reference forecast consumption.

These two segments account for 31% (21% from high-rise multi-family and 10% from low-income multi-family) of potential in 2038, but are forecast to consume (together) only 14% of the natural gas used by the residential sector in that year. As in the case of the electricity potential, the key driver here is the availability in large multi-family buildings of commercial building systems, and the opportunity in these segments for building automation systems and recommissioning.

Top Residential End Uses

As expected, space heating and the “All (Multiple End Uses)” end use account for almost all residential natural gas savings.

Top Residential Measures

The highest potential measures for single family buildings tend to be retrofits, rather than equipment replacement. The two measures that contribute the most to natural gas potential are adaptive thermostats (assumed to replace a mix of manual and programmable thermostats) and comprehensive draft proofing. These two measures are the top two contributors to potential in two of the three scenarios, and amongst the top three in Scenario B. This result is a combination of the low market saturation of these measures, and their relatively attractive payback.

Of the 10 measures contributing the highest potential in 2038, only two (high efficiency fireplace and condensing boilers, together accounting for 15% of residential potential) are single family home equipment measures. Of the remaining seven measures (which account for 75% of the sectoral potential in 2038): three are measures that apply only to multi-family buildings (make up air units, recommissioning or automation systems – 18% of potential) and the remaining five (57% of 2038 potential) are retrofit measures: basement and attic insulation, draft proofing and air sealing, and adaptive thermostat use. The reason for this is simply that heating system standards have become increasingly stringent meaning that (for example) forced air furnaces more efficient than the baseline have very long paybacks and tend not to be cost-effective.

Commercial

Year	2023	Percent of total sectoral energy savings	2038	Percent of total sectoral energy savings
Top Segments	Large Office	15%	Large Office	15%
	Other Commercial	14%	Other Commercial	15%
Top End Uses	Space Heating	81%	Space Heating	84%
	All (Multiple End Uses)	15%	All (Multiple End Uses)	13%
Top Measures	Boilers - Advanced Controls	13%	Condensing Boiler	12%
	Adaptive Thermostats	12%	Demand Control Ventilation	11%

Top Commercial Segments

The distribution of potential by segment is consistent across the study period. The most significant way in which the distribution across segments of commercial potential differs from forecast commercial consumption is that the other office segment is contributing disproportionately little potential – although this segment accounts for 15% of 2038 commercial potential, it accounts for 27% of forecast commercial consumption. The relatively low contribution to potential from this segment is driven by the end-use distribution: for this segment, the potential from the All (Multiple End Uses) end use accounts for only 3% of potential. In contrast, potential from this end use accounts for 15% of the total potential. It seems likely that the primary reason potential for this segment is low relative to the reference forecast is that this segment is dominated by smaller buildings that have fewer opportunities for energy efficiency via whole-building type measures.

Top Commercial End Uses

As seen on the residential natural gas side, Space Heating and All (Multiple End Uses) account for almost all residential natural gas savings with Space Heating contributing to seven times more potential than the “All (Multiple End Uses)” end use.

Top Commercial Measures

Unlike the residential sector, the measures contributing most to the commercial potential exhibit greater balance in terms of retrofits vs equipment with more efficient combustion. Three of the top 10 measures (condensing boilers, gas fired rooftop units, and gas fired heat pumps) fall into this latter category. Of the remaining seven measures in that top ten, five target natural gas savings through some type of ventilation improvement (demand control ventilation, building recommissioning, make up air units, air handlers and kitchen demand control ventilation). This finding in particular – that a high proportion of potential can be attained through ventilation measures that reduce natural gas space heating consumption – accords closely with feedback contributed by stakeholders attending the study’s Advisory Group meetings.

Industrial

Year	2023	Percent of total sectoral energy savings	2038	Percent of total sectoral energy savings
Top Segments	Plastic and Rubber Mfg	20%	Primary Metals Mfg	24%
	Agriculture	18%	Plastic and Rubber Mfg	19%
Top End Uses	Process Heating (Water/Steam)	39%	Process Heating (Direct)	57%
	Process Heating (Direct)	41%	Process Heating (Water/Steam)	25%
Top Measures	Boiler Upgrade	35%	Process Heat Improvements	31%
	Process Heat Improvements	20%	Boiler Upgrade	20%

Top Industrial Segments

The distribution of energy efficiency potential across segments is relatively stable over the reference forecast period, with material changes only in two segments: the agriculture segment accounts for 18% of industrial potential in 2023, but only 12% in 2038. In contrast, the primary metals manufacturing segment accounts for 18% of industrial potential in 2023, but 24% in 2038. This shift is due to the growth in the potential associated with direct process heating.

Top Industrial End Uses

The process heating (direct and water/steam) end uses account for over 80% of the potential of this sector, and represent approximately 71% of forecast industrial consumption.

Top Industrial Measures

Process heat improvements and boiler upgrades are the top contributors to the industrial potential through the course of the reference forecast period, and account for over half of the industrial potential. Other measures that contribute significant amounts of potential include gas heat recovery, recommissioning, and improved controls.

Whole Building Analysis

The Whole Building Analysis task was included in this APS to estimate energy efficiency potential using a top-down approach for a single segment to contrast with the bottom-up estimate of potential delivered as part of the core tasks of the engagement.

Navigant selected the hospitals segment for this task because whole building consumption and floor space data are publicly available. The primary objective of this task was to explore an econometric approach to projecting achievable potential, and to compare the results with the measure-based bottom-up model outputs.

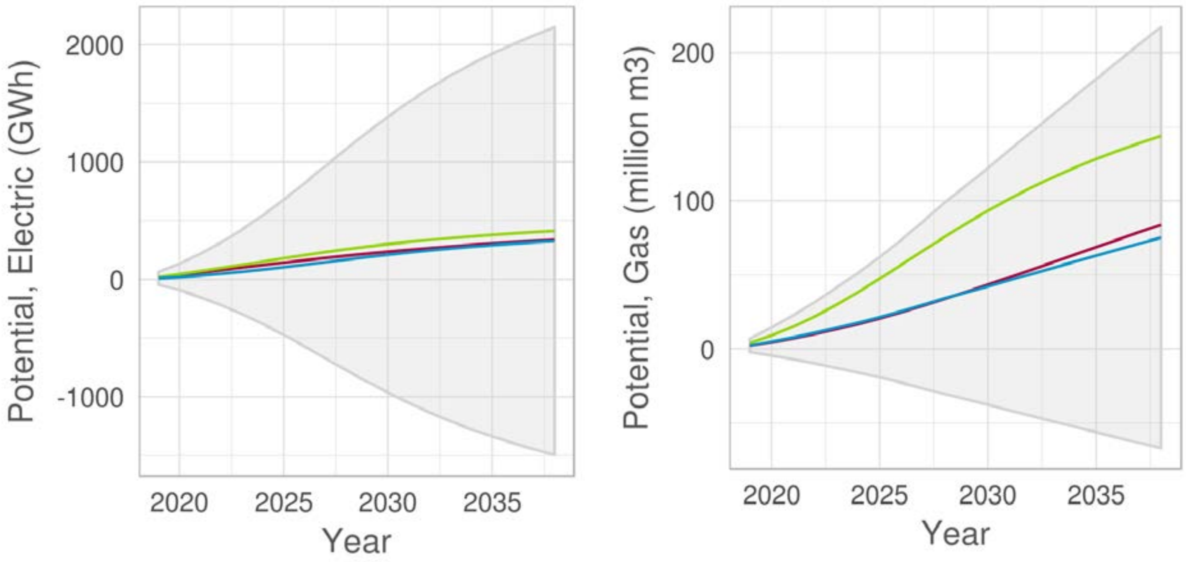
The top-down forecast of potential for the hospitals segment was estimated using the same incentive levels assumed for Scenario A (the constrained potential) and compared with the bottom-up results (referred to in the figure below as the “DSMSim Scenarios”). Navigant found that the projected potential for electric energy was approximately 1% higher for this segment than forecast by the bottom-up model (the model used to develop the overall potential estimates reported above) for 2038. The projected potential for natural gas was approximately 8% lower than that projected by the bottom-up model.

Although these results are very similar, Navigant noted two important points as an outcome of this analysis:

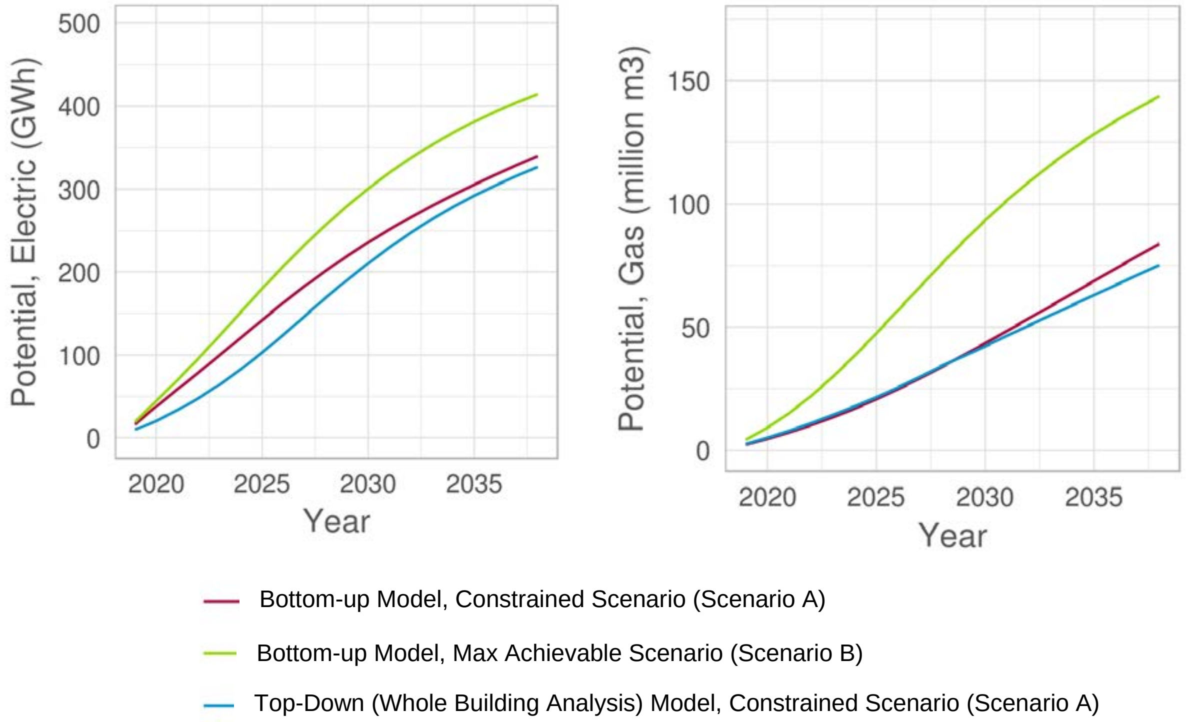
- Estimated top-down values were highly uncertain, with very wide confidence intervals (see the top two graphs in Figure ES-9)

- Results were highly sensitive to model specification – changes to the model specification could significantly alter the estimated outputs.

Figure ES-9. Comparison of Bottom-Up and WBA Model Estimated Potential – 2019-2038



Without Confidence Interval



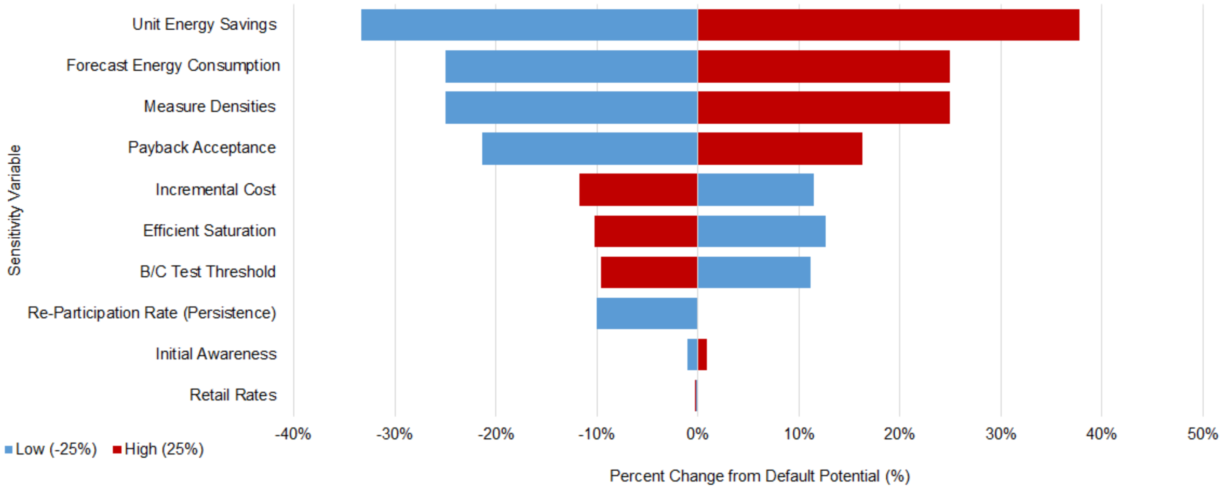
Source: Navigant analysis

Sensitivity Analysis

Navigant conducted a sensitivity analysis to identify which inputs and assumptions the natural gas and electric energy potential estimates were most sensitive to.

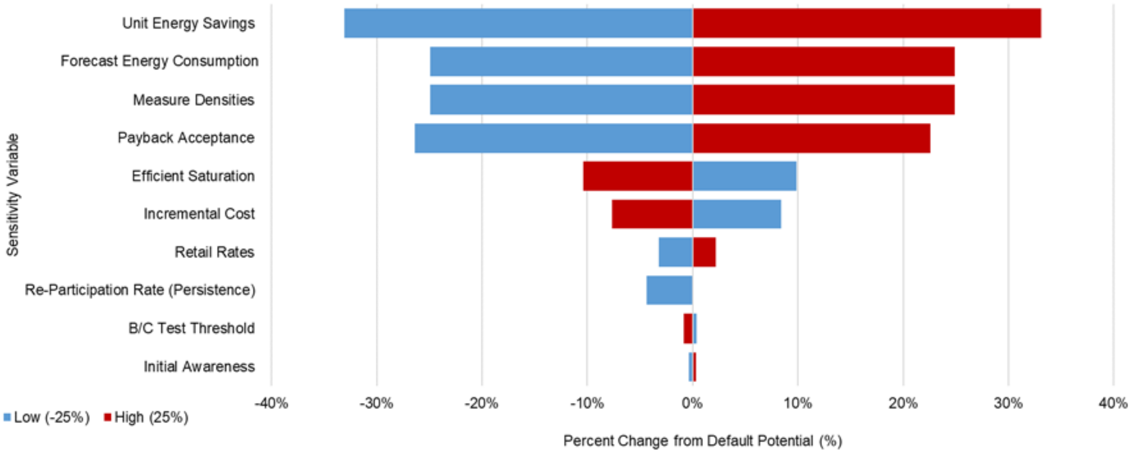
Figure ES-10 below, provides a summary of the sensitivity of the achievable potential to changes in various model parameters. For the sensitivity analysis, each parameter was adjusted upward and downward by 25% while other parameters were held constant. In each case (and for each parameter) total potential was recalculated and compared with the unadjusted outputs. The results displayed show the how much increasing and decreasing each input parameter by 25% affects the potential outputs..

Figure ES-10. Achievable Electricity Potential Sensitivity



Source: Navigant analysis

Figure ES-11. Achievable Natural Gas Potential Sensitivity



Source: Navigant analysis

Many of the results are as would be expected: potential is highly sensitive to changes in unit energy savings, forecast consumption, etc. One outcome that may initially appear counter-intuitive is how insensitive results appear to be to changes in retail rates.

For electricity, retail rates have a limited impact on electric energy achievable potential because of the low avoided costs of electricity. The low avoided costs necessitate that for measures to be cost-effective, the incremental costs must be low. Given that only cost-effective measures are considered in achievable potential, the measures are already extremely attractive to customers and their decision is minimally impacted by a change in the retail rates.

For natural gas, although potential is more sensitive than electric energy potential to retail rates, it still appears to be relatively insensitive. This has to do with the fact that consumer payback acceptance (how long a payback a consumer is willing to accept in adopting a measure) is non-linear and tends to have a relatively steep slope – only those measures that sit near the inflection points of the payback acceptance function will tend to be materially affected by a 25% change in rates.

Recommendations

This study marks the first integrated electricity and natural gas conservation potential study for the province of Ontario conducted by the IESO and the OEB.

This section summarises some key lessons from the development of this study and identifies where there are successes to retain for future studies, and where improvements could be made for the development of future studies.

Successes to Retain

Features of the current study that Navigant found greatly assisted with the work include the following:

- **Integration of electricity and natural gas analysis.** This study marks the first conservation potential study for the province of Ontario conducted by the IESO and the OEB capturing both natural gas and electric potential simultaneously. This provided opportunities for collaboration and resulted in consistent measure characterization, the capturing of full measure value (accounting for the summer peak demand savings benefit of dual-fuel measures) and providing confidence that both electricity and natural gas reference forecasts are compatible. The possibility of greater integration remains, and Navigant would recommend that the IESO and OEB consider aligning scenario constraints across fuels for future studies.
- **Residential End Use Data.** IESO's 2018 Residential End Use Survey (REUS) was valuable for both the electric and natural gas measures, ensuring that many key measure inputs (such as measure density and saturation) for the residential sector were based on locally specific findings, rather than assumptions derived from other jurisdictions.
- **Advisory Group input and third-party review of measure assumptions.** The APS AG provided valuable insights and expertise from the project initiation through to the implementation and presentation of results. This input as well as the review of measure level assumptions provided by the Measure Review Subcommittee helped ensure the study aligned with best practices in potential modelling and reflected the realities of the Ontario market.
- **Leveraging sector experts to understand customer behaviour.** The 2019 APS used a Delphi workshop approach to develop consumer measure adoption parameters (e.g., payback acceptance, awareness and ability to adopt, etc.). This process helped align the quantitative adoption inputs the experience of sector experts and also identified opportunities to improve program delivery and reduce market barriers.

Recommended Improvements

Navigant's complete list of recommended improvements for future studies may be found in Chapter 10. The four most important of Navigant's recommendations for improving future studies are provided below.

- **Collect commercial and industrial end use data.** Potential estimation would benefit significantly from up-to-date provincial baseline and end use studies, particularly for the commercial and industrial sectors. This information would help ensure assumptions about the current saturation of energy efficiency measures and remaining potential are better aligned with reality in the market.
- **Review and consolidate modelling zones.** 2019 APS modelling was done at the IESO transmission zonal level; however, many input assumptions were not at this level of granularity. Future studies should consider the availability of local data and consider streamlining modelling efforts by using fewer modelling zones.
- **Review frequency of APS updates.** Moving from a triennial to an annual or semi-biennial potential study cycle, could help align energy efficiency potential modelling with other electricity planning products (e.g., Annual Planning Outlook) and allow for more consistency and transparency between studies. Future study frequency could also align with sector-level data collection (e.g., end use studies).
- **Ensure the costs of natural gas expansion are properly accounted for within the natural gas avoided costs.** It is unclear to what degree the natural gas avoided costs currently account for the costs associated with natural gas infrastructure expansion, specifically the costs of installing pipelines (and associated equipment) to connect new developments to the natural gas distribution network.

TABLE OF CONTENTS

Executive Summary i
Background and Objectives i
Scope and Methodology i
Achievable Potential Scenarios ii
Forecast Potential Results iii
Whole Building Analysis xvii
Sensitivity Analysis xix
Recommendations xx
1. Introduction 1
1.1 Background and Objectives 1
1.2 Study Scope 2
1.3 Uncertainty and Precision 2
1.4 Report Structure 3
2. Base Year Disaggregation 5
2.1 Scope 5
2.2 Methodology 9
2.3 Results 11
3. Reference Forecast 21
3.1 Scope 21
3.2 Methodology 22
3.3 Results 26
4. Measure Characterisation 38
4.1 Scope 38
4.2 Methodology 38
4.3 Results 43
5. Technical Potential 44
5.1 Scope 44
5.2 Methodology 45
5.3 Results 49
6. Economic Potential 77
6.1 Scope 77
6.2 Methodology 78
6.3 Results 81
7. Achievable Potential Forecast 105
7.1 Scope 105
7.2 Methodology 107
7.3 Results 117

8. Whole Building Analysis 153
8.1 Scope 153
8.2 Methodology 153
8.3 Results 157
8.4 Key Findings and Recommendations 160
9. Sensitivity Analysis 162
9.1 Scope 162
9.2 Methodology 162
9.3 Results 164
10. Findings and Recommendations 172
10.1 Findings 172
10.2 Recommendations 184
Appendix A. Base Year Disaggregation A-1
A.1 Data Sources A-1
A.2 Detailed Methodology A-2
A.3 Results (Expanded) A-11
A.4 Definition of Natural Gas Regions A-15
Appendix B. Reference Forecast B-1
B.1 Data Sources B-1
B.2 Detailed Methodology B-1
B.3 Results (Expanded) B-5
B.4 Compatibility Assessment – Additional Detail B-13
Appendix C. Measure Characterisation C-1
C.1 Detailed Methodology C-1
Appendix D. Technical Potential D-1
D.1 Detailed Methodology D-1
D.2 Results (Expanded) D-3
Appendix E. Economic Potential E-1
E.1 Results (Expanded) E-1
Appendix F. Achievable Potential Forecast F-1
F.1 Detailed Methodology F-1
F.2 Results (Expanded) F-4
Appendix G. Whole Building Analysis G-1
G.1 Detailed Methodology G-1
G.2 Results (Expanded) G-6
Appendix H. Comparison with other Jurisdictions H-1

LIST OF TABLES

Table 2-1. Segments by Sector 8
Table 2-2. End Uses by Sector 9
Table 3-1. Summary of Compatibility Analysis 24
Table 4-1. Measure Characterisation Parameters 39
Table 5-1. Electric Energy Technical Potential as a Percentage of Forecast Consumption 51
Table 5-2. Natural Gas Energy Technical Potential as a Percentage of Forecast Consumption 54
Table 5-3. Top 20 Measures for Residential Electric Measure-Level Technical Potential in 2038 70
Table 5-4. Top 20 Measures for Commercial Electric Measure-Level Technical Potential in 2038 70
Table 5-5. Top 20 Measures for Industrial Electric Measure-Level Technical Potential in 2038 71
Table 5-6. Top 20 Measures for Residential Natural Gas Measure-Level Technical Potential in 2038 72
Table 5-7. Top 20 Measures for Commercial Natural Gas Measure-Level Technical Potential in 2038 73
Table 5-8. Top 20 Measures for Industrial Natural Gas Measure-Level Technical Potential in 2038 73
Table 6-1. Electric Energy Economic Potential as a Percentage of Forecast Consumption 83
Table 6-2. Natural Gas Energy Economic Potential as a Percentage of Forecast Consumption 86
Table 6-3. Top 20 Measures for Residential Electric Measure-Level Economic Potential in 2038 99
Table 6-4. Top 20 Measures for Commercial Electric Measure-Level Economic Potential in 2038 100
Table 6-5. Top 20 Measures for Industrial Electric Measure-Level Economic Potential in 2038 100
Table 6-6. Top 20 Measures for Residential Natural Gas Measure-Level Economic Potential in 2038 101
Table 6-7. Top 20 Measures for Commercial Natural Gas Measure-Level Economic Potential in 2038 102
Table 6-8. Top 20 Measures for Industrial Natural Gas Measure-Level Economic Potential in 2038 103
Table 7-1. Constrained Scenario Incentive Approach 112
Table 7-2. Maximum Scenario Incentive Approach 113
Table 7-3. Semi-Constrained Scenario Incentive Approach 113
Table 7-4. Demand-Targeted Scenario Incentive Approach 114
Table 7-5. Administrative Costs Approaches by Scenario 116
Table 7-6. Electric Energy Potential by Scenario (GWh) 118
Table 7-7. Electric Summer Peak Demand Potential by Scenario (MW) 119
Table 7-8. Natural Gas Potential by Scenario (Million of m^3) 121
Table 7-9. Top 20 Measures for Electric Energy Achievable Savings Potential for Scenario A in 2038 (GWh) 126
Table 7-10. Top 20 Measures for Natural Gas Energy Achievable Savings Potential for Scenario A in 2038 (Million m^3) 126
Table 7-11. Top 20 Measures for Electric Energy Achievable Savings Potential for Scenario B in 2038 (GWh) 127
Table 7-12. Top 20 Measures for Natural Gas Energy Achievable Savings Potential for Scenario B in 2038 (Million m^3) 128
Table 7-13. Top 20 Measures for Electric Energy Achievable Savings Potential for Scenario C in 2038 (GWh) 129
Table 7-14. Top 20 Measures for Natural Gas Energy Achievable Savings Potential for Scenario C in 2038 (Million m^3) 129
Table 7-15. Top 20 Measures for Electric Summer Peak Demand Achievable Savings Potential for Scenario D in 2038 (MW) 131
Table 7-16. Top 20 Measures for Electric Energy Achievable Savings Potential for Scenario A in 2038 (GWh) 134
Table 7-17. Top 20 Measures for Natural Gas Energy Achievable Savings Potential for Scenario A in 2038 (Million m^3) 135
Table 7-18. Top 20 Measures for Electric Energy Achievable Savings Potential for Scenario B in 2038 (GWh) 136
Table 7-19. Top 20 Measures for Natural Gas Energy Achievable Savings Potential for Scenario B in 2038 (Million m^3) 137
Table 7-20. Top 20 Measures for Electric Energy Achievable Savings Potential for Scenario C in 2038 (GWh) 137

Table 7-21. Top 20 Measures for Natural Gas Energy Achievable Savings Potential for Scenario C in 2038 (Million m^3) 138
Table 7-22. Top 20 Measures for Electric Summer Peak Demand Achievable Savings Potential for Scenario D in 2038 (MW)....139
Table 7-23. Top 20 Measures for Electric Energy Achievable Savings Potential for Scenario A in 2038 (GWh)....143
Table 7-24. Top 20 Measures for Natural Gas Energy Achievable Savings Potential for Scenario A in 2038 (Million m^3) 145
Table 7-25. Top 20 Measures for Electric Energy Achievable Savings Potential for Scenario B in 2038 (GWh)....145
Table 7-26. Top 20 Measures for Natural Gas Energy Achievable Savings Potential for Scenario B in 2038 (Million m^3) 146
Table 7-27. Top 20 Measures for Electric Energy Achievable Savings Potential for Scenario C in 2038 (GWh)....147
Table 7-28. Top 20 Measures for Natural Gas Energy Achievable Savings Potential for Scenario C in 2038 (Million m^3) 148
Table 7-29. Top 20 Measures for Electric Summer Peak Demand Achievable Savings Potential for Scenario D in 2038 (MW)....148
Table 10-1. Provincial Electricity Results....173
Table 10-2. Provincial Natural Gas Results....173
Table 10-3. Residential Electricity Results....177
Table 10-4. Residential Natural Gas Results....178
Table 10-5. Commercial Electricity Results 180
Table 10-6. Commercial Natural Gas Results 180
Table 10-7. Industrial Electricity Results....182
Table 10-8. Industrial Natural Gas Results....183

Table A-1. Data Sources Used A-1
Table A-2. Residential Low Income Households A-3
Table A-3. Residential Gas Fuel Shares by IESO Zone....A-5
Table A-4. Commercial Floor Space Stock by Segment A-6
Table A-5. Calibrated Commercial Natural Gas Fuel Share by IESO Zone A-7
Table A-6. Industrial Segment Definitions....A-8
Table A-7. Industrial End Use Allocation Factors (Electric) A-9
Table A-8. Industrial Natural Gas Allocation Factor Mapping (MECS) A-10
Table A-9. Industrial Natural Gas Allocation Factors....A-11
Table B-1. Data Sources Used B-1
Table B-2. Global Assumptions Summary....B-13
Table B-3. Sectoral Assumptions Summary B-14
Table C-1. Residential Energy Efficiency Measure List....C-1
Table C-2. Residential Energy Efficiency Multifamily Measures....C-5
Table C-3. Residential Fuel Switching Measure List C-7
Table C-4. Commercial Energy Efficiency Measure List C-7
Table C-5. Commercial Fuel Switching Measure List....C-14
Table C-6. Industrial Energy Efficiency Measure List....C-14
Table C-7. Mapped End Use Profiles to DR-Enabling Energy Efficiency Measures....C-20
Table C-8. Residential Unit Impact Assumptions C-20
Table C-9. Commercial Unit Impact Assumptions....C-21
Table E-1. Residential Electricity – Technical and Economic Potential in 2038....E-12
Table E-2. Commercial Electricity – Technical and Economic Potential in 2038 ....E-14
Table E-3. Industrial Electricity – Technical and Economic Potential in 2038....E-17
Table E-4. Residential Natural Gas – Technical and Economic Potential in 2038....E-18
Table E-5. Commercial Natural Gas – Technical and Economic Potential in 2038....E-19
Table E-6. Industrial Natural Gas – Technical and Economic Potential in 2038 ....E-21

Table G-1. Achievable Potential Benchmarking Results – Electricity G-8
Table G-2. Achievable Potential Benchmarking Results – Natural Gas G-10

LIST OF FIGURES

Figure 1-1. Program Process Flow 2
Figure 2-1. Illustrative Breakdown of Base Year Disaggregation 5
Figure 2-2. IESO Zones and Natural Gas Utility Regions 6
Figure 2-3. Total Consumption by Fuel Type 12
Figure 2-4. Residential Electricity and Natural Gas Consumption by Segment, Province 13
Figure 2-5. Residential Electricity Consumption by IESO Zone 13
Figure 2-6. Residential Natural Gas Consumption by Natural Gas Region 14
Figure 2-7. Residential Electricity and Natural Gas Consumption by End Use, Province 14
Figure 2-8. Commercial Natural Gas and Electricity Consumption by Segment, Province 15
Figure 2-9. Commercial Electricity Consumption by IESO Zone 16
Figure 2-10. Commercial Natural Gas Consumption by Natural Gas Region 16
Figure 2-11. Commercial Consumption by End Use, Province 17
Figure 2-12. Industrial Consumption by Segment, Province 18
Figure 2-13. Industrial Electricity Consumption by IESO Zone 19
Figure 2-14. Industrial Natural Gas Consumption by Natural Gas Region 19
Figure 2-15. Industrial Natural Gas and Electricity Consumption by End Use, Province 20
Figure 3-1. Challenges with Comparing Electricity and Natural Gas Forecasts 23
Figure 3-2. Total Consumption by Sector and Year (Electricity and Natural Gas) 27
Figure 3-3. Electricity Sectoral Shares 27
Figure 3-4. Natural Gas Sectoral Shares 28
Figure 3-5. Total Residential Consumption by Year (Natural Gas and Electricity) 28
Figure 3-6. Residential Natural Gas Consumption by Year, by Natural Gas Region 29
Figure 3-7. Residential Electricity Consumption by Year, by IESO Zone 29
Figure 3-8. Residential Consumption by Segment (Natural Gas and Electricity) 30
Figure 3-9. Residential Consumption by End Use (Natural Gas and Electricity) 30
Figure 3-10. Total Commercial Consumption by Year (Natural Gas and Electricity) 31
Figure 3-11. Commercial Natural Gas Consumption by Year, by Natural Gas Region 32
Figure 3-12. Commercial Electricity Consumption by Year, by IESO Zone 32
Figure 3-13. Commercial Consumption by Segment (Natural Gas and Electricity) 33
Figure 3-14. Commercial Consumption by End Use (Natural Gas and Electricity) 33
Figure 3-15. Total Industrial Consumption by Year (Natural Gas and Electricity) 34
Figure 3-16. Industrial Natural Gas Consumption by Year, by Natural Gas Region 35
Figure 3-17. Industrial Electricity Consumption by Year, by IESO Zone 35
Figure 3-18. Industrial Consumption by Segment (Natural Gas and Electricity) 36
Figure 3-19. Industrial Consumption by End Use (Natural Gas and Electricity) 36
Figure 4-1. Measure Categorisation 40
Figure 5-1. Venn Diagrams for Various Efficiency Stacking Situations 49
Figure 5-2. Electric Energy Technical Potential by Sector (GWh) 50
Figure 5-3. Electric Energy Reference Forecast and Technical Potential 51
Figure 5-4. Electric Summer Demand Technical Potential by Sector (MW) 52
Figure 5-5. Natural Gas Energy Technical Potential by Sector (Million m^3) 53
Figure 5-6. Natural Gas Reference Forecast and Technical Potential 54
Figure 5-7. Residential Electric Energy Technical Potential by End Use (GWh) 55

Figure 5-8. Residential Electric Energy Technical Potential by End Use as a Percentage of End Use Forecast Consumption 56
Figure 5-9. Residential Electric Demand Technical Potential by End Use (MW) 57
Figure 5-10. Commercial Electric Energy Technical Potential by End Use (GWh) 58
Figure 5-11. Commercial Electric Energy Technical Potential by End Use as a Percentage of End Use Forecast Consumption 59
Figure 5-12. Commercial Electric Demand Technical Potential by End Use (MW) 60
Figure 5-13. Industrial Electric Energy Technical Potential by End Use (GWh) 61
Figure 5-14. Industrial Electric Energy Technical Potential by End Use as a Percentage of End Use Forecast Consumption 62
Figure 5-15. Industrial Electric Demand Technical Potential by End Use (MW) 63
Figure 5-16. Residential Natural Gas Energy Technical Potential by End Use (Million m^3) 64
Figure 5-17. Residential Natural Gas Energy Technical Potential by End Use as a Percentage of End Use Forecast Consumption 65
Figure 5-18. Commercial Natural Gas Energy Technical Potential by End Use (Million m^3) 66
Figure 5-19. Commercial Natural Gas Energy Technical Potential by End Use as a Percentage of End Use Forecast Consumption 67
Figure 5-20. Industrial Natural Gas Energy Technical Potential by End Use (Million m^3) 68
Figure 5-21. Industrial Natural Gas Energy Savings Potential by End Use as a Percentage of End Use Forecast Consumption 69
Figure 5-22. Electric Technical Emissions Reduction Potential by Sector (Thousand tCO2e) 74
Figure 5-23. Electricity Emissions Intensity 75
Figure 5-24. Natural Gas Emissions Reduction Savings Potential by Sector (Thousand tCO2e) 76
Figure 6-1. Electric Energy Economic Potential by Sector (GWh) 82
Figure 6-2. Electric Energy Reference Forecast and Economic Potential 83
Figure 6-3. Electric Summer Demand Economic Potential by Sector (MW) 84
Figure 6-4. Natural Gas Economic Potential by Sector (Million m^3) 85
Figure 6-5. Natural Gas Reference Forecast and Economic Potential 86
Figure 6-6. Residential Electric Energy Economic Potential by End Use (GWh) 87
Figure 6-7. Residential Electric Energy Economic Potential by End Use as a Percentage of End Use Forecast Consumption 88
Figure 6-8. Commercial Electric Energy Economic Potential by End Use (GWh) 89
Figure 6-9. Commercial Electric Energy Economic Potential by End Use as a Percentage of End Use Forecast Consumption 90
Figure 6-10. Industrial Electric Energy Economic Potential by End Use (GWh) 91
Figure 6-11. Industrial Electric Energy Economic Potential by End Use as a Percentage of End Use Forecast Consumption 92
Figure 6-12. Residential Natural Gas Economic Potential by End Use (Million m^3) 93
Figure 6-13. Residential Natural Gas Energy Economic Potential by End Use as a Percentage of End Use Forecast Consumption 94
Figure 6-14. Commercial Natural Gas Economic Potential by End Use (Million m^3) 95
Figure 6-15. Commercial Natural Gas Energy Economic Potential by End Use as a Percentage of End Use Forecast Consumption 96
Figure 6-16. Industrial Natural Gas Economic Potential by End Use (Million m^3) 97
Figure 6-17. Industrial Natural Gas Energy Economic Potential by End Use as a Percentage of End Use Forecast Consumption 98
Figure 6-18. Electric Energy Economic Emissions Reduction Potential by Sector (Thousand tCO2e) 104
Figure 6-19. Natural Gas Energy Economic Emissions Savings Potential by Sector (Thousand tCO2e)104
Figure 7-1. Summary of Achievable Potential Scenarios 112
Figure 7-2. Electric Energy Achievable Savings Potential by Sector and Scenario in 2038 (GWh) 118
Figure 7-3. Electric Summer Peak Demand Achievable Savings Potential by Sector and Scenario in 2038 (MW) 119
Figure 7-4. Natural Gas Energy Achievable Savings Potential by Sector and Scenario in 2038 (Million m^3) 120

Figure 7-5. Electric Energy Achievable Cost by Sector and Scenario (Million $/year) 122
Figure 7-6. Natural Gas Energy Achievable Program Cost by Sector and Scenario (Million $/year) 123
Figure 7-7. Electric Energy Achievable Savings Potential by End Use and Scenario in 2038 (GWh) 124
Figure 7-8. Electric Summer Peak Demand Achievable Savings Potential by End Use and Scenario in 2038 (MW) 124
Figure 7-9. Natural Gas Energy Achievable Savings Potential by End Use and Scenario in 2038 (Million m^3) 125
Figure 7-10. Electric Energy Achievable Savings Potential by End Use and Scenario in 2038 (GWh) 132
Figure 7-11. Electric Summer Peak Demand Achievable Savings Potential by End Use and Scenario in 2038 (MW) 133
Figure 7-12. Natural Gas Energy Achievable Savings Potential by end use and scenario in 2038 (Million m^3) 134
Figure 7-13. Electric Energy Achievable Savings Potential by End Use and Scenario in 2038 (GWh) 141
Figure 7-14. Electric Summer Peak Demand Achievable Savings Potential by End Use and Scenario in 2038 (MW) 142
Figure 7-15. Natural Gas Energy Achievable Savings Potential by End Use and Scenario in 2038 (Million m^3) 142
Figure 7-16. Electric Energy Emissions Reduction Potential by Sector (Thousand tCO2e) – Scenario A 149
Figure 7-17. Natural Gas Energy Emissions Savings Potential by Sector (Thousand tCO2e) – Scenario A 150
Figure 7-18. Electric Energy Emissions Reduction Potential by Sector (Thousand tCO2e) – Scenario B 150
Figure 7-19. Natural Gas Energy Emissions Savings Potential by Sector (Thousand tCO2e) – Scenario B 151
Figure 7-20. Electric Energy Emissions Reduction Potential by Sector (Thousand tCO2e) – Scenario C 151
Figure 7-21. Natural Gas Energy Emissions Savings Potential by Sector (Thousand tCO2e) – Scenario C 152
Figure 7-22. Electric Energy Emissions Reduction Potential by Sector (Thousand tCO2e) – Scenario D 152
Figure 8-1. Basic and Enhanced Model Overview 155
Figure 8-2. Geographic Dispersion of Hospitals in the BPS Dataset 156
Figure 8-3. Cumulative Commercial Sector Historical and Forecast Incentives – 2019-2038 157
Figure 8-4. Basic Model Forecast Conservation Potential – 2019-2038 158
Figure 8-5. Enhanced Model Forecast Conservation Potential – 2019-2038 159
Figure 8-6. Comparison of Basic and Enhanced Models – 2018-2038 160
Figure 9-1. Electric Energy Technical Potential for the Portfolio in 2038 (%) 165
Figure 9-2. Natural Gas Energy Technical Potential for the Portfolio in 2038 (%) 165
Figure 9-3. Electric Energy Technical Potential by Sector in 2038 (%) 166
Figure 9-4. Natural Gas Energy Technical Potential in 2038 (%) 166
Figure 9-5. Electric Energy Economic Potential for the Portfolio in 2038 (%) 167
Figure 9-6. Natural Gas Energy Economic Potential for the Portfolio in 2038 (%) 168
Figure 9-7. Electric Energy Economic Potential by Sector in 2038 (%) 168
Figure 9-8. Natural Gas Energy Economic Potential by Sector in 2038 (%) 169
Figure 9-9. Electric Energy Achievable Savings Potential for the Portfolio in 2038 (%) 170
Figure 9-10. Natural Gas Energy Achievable Savings Potential for the Portfolio in 2038 (%) 170
Figure 9-11. Electric Energy Achievable Savings Potential by Sector in 2038 (%) 171
Figure 9-12. Natural Gas Energy Achievable Savings Potential by Sector in 2038 (%) 171

Figure A-1. Residential Energy Intensity by Segment, Province A-12
Figure A-2. Residential Energy Intensity by End Use, Province A-13
Figure A-3. Commercial Energy Intensity by Segment, Province A-13

Figure A-4. Commercial Energy Intensity by End Use, Province A-14
Figure B-1. Residential Energy Intensity by Segment (Electricity and Natural Gas) B-6
Figure B-2. Residential Energy Intensity by End Use (Electricity and Natural Gas) B-6
Figure B-3. Residential Stock Forecast (Households) by IESO Zone and Segment B-7
Figure B-4. Residential Stock Forecast (Natural Gas-Connected Households) by Natural Gas Region and Segment B-8
Figure B-5. Commercial Energy Intensity by Segment (Natural Gas and Electricity) B-9
Figure B-6. Commercial Energy Intensity by End Use (Natural Gas and Electricity) B-10
Figure B-7. Commercial Stock Forecast (Square Footage) by IESO Zone and Segment B-10
Figure B-8. Commercial Stock Forecast (Natural Gas-Connected Square Footage) by Natural Gas Region and Segment B-12
Figure D-1. Residential Electric Energy Technical Potential by Customer Segment (GWh) D-4
Figure D-2. Residential Electric Demand Technical Potential by Customer Segment (MW) D-5
Figure D-3. Residential Natural Gas Energy Technical Potential by Customer Segment (Million m^3) D-6
Figure D-4. Commercial Electric Energy Technical Potential by Customer Segment (GWh) D-7
Figure D-5. Commercial Electric Demand Technical Potential by Customer Segment (MW) D-8
Figure D-6. Commercial Natural Gas Energy Technical Potential by Customer Segment (Million m^3) D-9
Figure D-7. Industrial Electric Energy Technical Potential by Customer Segment (GWh) D-10
Figure D-8. Industrial Electric Demand Technical Potential by Customer Segment (MW) D-11
Figure D-9. Industrial Natural Gas Energy Technical Potential by Customer Segment (Million m^3) D-12
Figure D-10. Electric Energy Reference Forecast and Technical Electrification Potential D-13
Figure D-11. Residential Electric Energy Technical Fuel Switching Savings Potential by End Use (GWh) D-14
Figure D-12. Commercial Electric Energy Technical Fuel Switching Savings Potential by End Use (GWh) D-15
Figure D-13. Natural Gas Reference Forecast and Fuel Switching Technical Potential (Million m^3) D-16
Figure D-14. Residential Natural Gas Technical Fuel Switching Savings Potential by End Use (Million m^3) D-17
Figure D-15. Commercial Natural Gas Technical Fuel Switching Savings Potential by End Use (Million m^3) D-18
Figure D-16. Electric Demand Response Technical Potential by Sector (MW) D-19
Figure E-1. Residential Electric Energy Economic Potential by Customer Segment (GWh) E-1
Figure E-2. Residential Electric Demand Technical Potential by Customer Segment (MW) E-2
Figure E-3. Residential Natural Gas Energy Economic Potential by Customer Segment (Million m^3) E-3
Figure E-4. Commercial Electric Energy Economic Potential by Customer Segment (GWh) E-4
Figure E-5. Commercial Electric Demand Technical Potential by Customer Segment (MW) E-5
Figure E-6. Commercial Natural Gas Energy Economic Potential by Customer Segment (Million m^3) E-6
Figure E-7. Industrial Electric Energy Economic Potential by Customer Segment (GWh) E-7
Figure E-8. Industrial Electric Demand Technical Potential by Customer Segment (MW) E-8
Figure E-9. Industrial Natural Gas Energy Economic Potential by Customer Segment (Million m^3) E-9
Figure E-10. Electric Energy Reference Forecast and Economic Electrification Potential E-10
Figure E-11. Electric Demand Response Economic Potential by Sector (MW) E-11
Figure F-1. Residential Low-Cost Payback Acceptance Curves F-1
Figure F-2. Residential High-Cost Payback Acceptance Curves F-2
Figure F-3. Residential Average Payback Acceptance Curve F-2
Figure F-4. Commercial Average Payback Acceptance Curves F-3
Figure F-5. Industrial Average Payback Acceptance Curves F-3
Figure F-6. Electric Energy Achievable Savings Potential by Customer Segment and Scenario in 2038 (GWh) F-4
Figure F-7. Electric Summer Peak Demand Achievable Savings Potential by Customer Segment and Scenario in 2038 (MW) F-5
Figure F-8. Natural Gas Energy Achievable Savings Potential by Customer Segment and Scenario in 2038 (Million m^3) F-6

Figure F-9. Electric Energy Achievable Savings Potential by Customer Segment and Scenario in 2038 (GWh) F-7
Figure F-10. Electric Summer Peak Demand Achievable Savings Potential by Customer Segment and Scenario in 2038 (MW) F-8
Figure F-11. Natural Gas Energy Achievable Savings Potential by Customer Segment and Scenario in 2038 (Million m^3) F-9
Figure F-12. Electric Energy Achievable Savings Potential by Customer Segment and Scenario in 2038 (GWh) F-10
Figure F-13. Electric Energy Achievable Savings Potential as a Percent of Reference Forecast by Customer Segment and Scenario (%) F-11
Figure F-14. Electric Summer Peak Demand Achievable Savings Potential by Customer Segment and Scenario in 2038 (MW) F-12
Figure F-15. Natural Gas Energy Achievable Savings Potential by Customer Segment and Scenario in 2038 (Million m^3) F-13
Figure F-16. Electric Demand Response Economic Potential by Sector (MW) – Scenario A F-14
Figure F-17. Electric Demand Response Economic Potential by Sector (MW) – Scenario B F-15
Figure F-18. Electric Demand Response Economic Potential by Sector (MW) – Scenario C F-15
Figure F-19. Electric Demand Response Economic Potential by Sector (MW) – Scenario D F-16
Figure F-20. Electric Energy Cost Curve, Scenario A in 2023 ..... F-17
Figure F-21. Electric Summer Peak Demand Cost Curve, Scenario A in 2023 ..... F-17
Figure F-22. Natural Gas Energy Cost Curve, Scenario A in 2023 ..... F-18
Figure F-23. Electric Energy Cost Curve, Scenario A in 2030 ..... F-18
Figure F-24. Electric Summer Peak Demand Cost Curve, Scenario A in 2030 ..... F-19
Figure F-25. Natural Gas Energy Cost Curve, Scenario A in 2030 ..... F-19
Figure F-26. Electric Energy Cost Curve, Scenario A in 2038 ..... F-20
Figure F-27. Electric Summer Peak Demand Cost Curve, Scenario A in 2038 ..... F-20
Figure F-28. Natural Gas Energy Cost Curve, Scenario A in 2038 ..... F-21
Figure F-29. Electric Energy Cost Curve, Scenario B in 2023 ..... F-22
Figure F-30. Electric Summer Peak Demand Cost Curve, Scenario B in 2023 ..... F-22
Figure F-31. Natural Gas Energy Cost Curve, Scenario B in 2023 ..... F-23
Figure F-32. Electric Energy Cost Curve, Scenario B in 2030 ..... F-23
Figure F-33. Electric Summer Peak Demand Cost Curve, Scenario B in 2030 ..... F-24
Figure F-34. Natural Gas Energy Cost Curve, Scenario B in 2030 ..... F-24
Figure F-35. Electric Energy Cost Curve, Scenario B in 2038 ..... F-25
Figure F-36. Electric Summer Peak Demand Cost Curve, Scenario B in 2038 ..... F-25
Figure F-37. Natural Gas Energy Cost Curve, Scenario B in 2038 ..... F-26
Figure F-38. Electric Energy Cost Curve, Scenario C in 2023 ..... F-27
Figure F-39. Electric Summer Peak Demand Cost Curve, Scenario C in 2023 ..... F-27
Figure F-40. Natural Gas Energy Cost Curve, Scenario C in 2023 ..... F-28
Figure F-41. Electric Energy Cost Curve, Scenario C in 2030 ..... F-28
Figure F-42. Electric Summer Peak Demand Cost Curve, Scenario C in 2030 ..... F-29
Figure F-43. Natural Gas Energy Cost Curve, Scenario C in 2030 ..... F-29
Figure F-44. Electric Energy Cost Curve, Scenario C in 2038 ..... F-30
Figure F-45. Electric Summer Peak Demand Cost Curve, Scenario C in 2038 ..... F-30
Figure F-46. Natural Gas Energy Cost Curve, Scenario C in 2038 ..... F-31
Figure F-47. Electric Energy Cost Curve, Scenario D in 2023 ..... F-32
Figure F-48. Electric Summer Peak Demand Cost Curve, Scenario C in 2023 ..... F-32
Figure F-49. Electric Energy Cost Curve, Scenario D in 2030 ..... F-33
Figure F-50. Electric Summer Peak Demand Cost Curve, Scenario C in 2030 ..... F-33
Figure F-51. Electric Energy Cost Curve, Scenario D in 2038 ..... F-34
Figure F-52. Electric Summer Peak Demand Cost Curve, Scenario C in 2038 ..... F-34
Figure G-1. Examples of Outlier Observations of Consumption G-4
Figure G-2. Illustration of Outlier Removal for Each Building G-5
Figure G-3. Technical Potential Benchmarking – Electricity G-6

Figure G-4. Technical Potential Benchmarking – Natural Gas G-7
Figure G-5. Economic Potential Benchmarking – Electricity G-7
Figure G-6. Economic Potential Benchmarking – Natural Gas G-8
Figure G-7. Scenario A Potential Benchmarking – Electricity G-9
Figure G-8. Scenario B Potential Benchmarking – Electricity G-9
Figure G-9. Scenario C Potential Benchmarking – Electricity G-10
Figure G-10. Scenario A Potential Benchmarking – Natural Gas G-10
Figure G-11. Scenario B Potential Benchmarking – Natural Gas G-11
Figure G-12. Scenario C Potential Benchmarking – Natural Gas G-11

1. INTRODUCTION

In the summer of 2018, Navigant Consulting Ltd. (Navigant) was engaged to prepare an energy efficiency APS for electricity and natural gas across Ontario over a 20-year period, from 2019 to 2038.

This introduction to the APS is divided into four sections:

- **Background and Objectives.** Provides context for this study and identifies what this study seeks to accomplish.
- **Study Scope.** Outlines the scope of this APS.
- **Uncertainty and Precision.** Describes some of the key input uncertainties associated with this study that those using this report should consider in using its outputs for any additional analysis.
- **Report Structure.** Provides a capsule description of the remaining chapters in this report.

1.1 Background and Objectives

The main objective of the APS is to identify and quantify achievable potential energy savings (electricity and natural gas) and greenhouse gas (GHG) emissions reductions, and the costs associated with delivering this potential for the period of 2019-2038. The APS will provide data and analysis to inform:

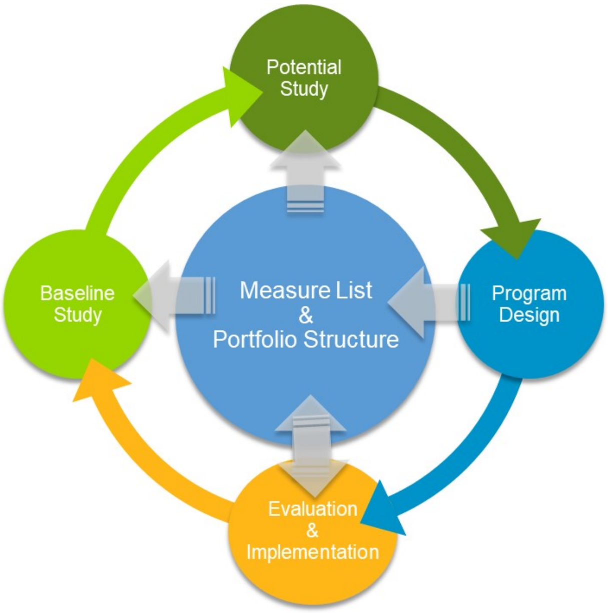
- The development of future conservation policy and/or frameworks
- Program design, implementation and evaluations
- Long-term resource planning and system operations

In previous cycles, the IESO and the OEB have commissioned separate studies of electricity and natural gas potential in the province. This 2019 study differs from previous studies in that it covers both electricity and natural gas in a single modelling effort, delivering an integrated study of electricity and natural gas energy efficiency potential.

Figure 1-1 illustrates the cycle of potential studies and related energy efficiency activities. This figure illustrates the continuous process of defining the baseline energy use of the market through baseline or saturation studies, forecasting the potential energy savings across a market (the development of an APS), developing and evaluating efficiency programs designed to achieve savings, and then redefining the baseline based on programmatic impacts on efficiency improvements. This process flow ensures the market is served based on the energy consumer’s needs by providing:

- Foundation for program planning
- Basis for long-term goals and targets
- Direction for the development of new services and initiatives

Figure 1-1. Program Process Flow



Source: Navigant analysis

1.2 Study Scope

The scope of this study is summarised below:

- **Sector Coverage:** The study addresses three sectors: residential, commercial, and industrial. In this study, the residential sector includes all multi-family residential buildings (including high rises). The commercial sector includes institutional and governmental sub-sectors (referred to in this study as "segments"), such as hospitals and schools.
- **Geographic Coverage:** Projected savings potential are estimated separately for each of the 10 IESO transmission zones, and allocated (as described in the base year disaggregation sector) to five natural gas regions. Most results reported in this study are aggregated to the provincial level, although more zonal and regional potential estimates are outputs of this analysis.
- **Reference Forecast Period:** This study covers a 20-year period from 2019 through 2038. The base year for the study is calendar year 2017, the most recent complete calendar year for which historical data were available at the time the study began.
- **Technologies:** This study considers contributions to provincial energy efficiency potential from 207 electric-only measures, 70 natural gas-only measures and 80 dual fuel measures. This study also considers contributions to fuel switching potential (natural gas to electricity only) of eight fuel switching measures.

1.3 Uncertainty and Precision

The analysis and outputs of this study depend on a large number of inputs, all of which are estimates of one form or another: estimates of measure savings, forecasts of future consumption, assumptions regarding future inflation rates, etc. Navigant has worked to ensure that, as much as possible, key global assumptions and individual measure assumptions are aligned with those used by the OEB and the IESO.

However, all estimates are, by definition, uncertain, which necessarily means that estimated outputs must also be uncertain.

Navigant has approximately quantified the band of uncertainty surrounding the point estimates presented in this study through a sensitivity analysis which quantifies the degree to which outputs change as key input parameter values are adjusted. The precision of forecast potential implied by that sensitivity analysis should borne in mind when working with these results, particularly when working with the more granular outputs of this study.

1.4 Report Structure

The remainder of this report is divided into nine chapters, corresponding with key tasks and deliverables associated with this study. These are:

- **Base Year Disaggregation.** This chapter defines the granularity of study outputs and allowed Navigant to develop an approach for mapping electricity and natural gas forecasts to the required level of granularity. The base year data (consumption, etc.) used to accomplish this task was 2017, the most recent full calendar year for which historical data were available.
- **Reference Forecast.** This chapter describes how Navigant used the IESO and natural gas utilities' forecasts of energy consumption, and the outputs of the base year disaggregation to develop a combined reference forecast of energy consumption in the province that aligns with the granularity established for this study as part of the base year disaggregation.
- **Measure Characterisation.** This chapter describes how Navigant defined, based on the best available data, the characteristics of energy efficiency and fuel switching measures considered by the study, such as measure savings, costs, and existing market share (saturation).
- **Technical Potential.** This chapter describes how Navigant estimated the hypothetical energy efficiency potential under the assumption that all baseline technologies are replaced by the energy efficiency measures that deliver the most savings, as soon as possible, where it is technically feasible to do so, and provides the estimated technical potential for both fuels.
- **Economic Potential.** This chapter describes how Navigant estimated the hypothetical energy efficiency potential under the assumption that all baseline technologies are replaced by the *cost-effective* energy efficiency measures that deliver the most savings, as soon as possible, where it is technically feasible to do so, and provides the estimated technical potential for both fuels.
- **Achievable Potential Forecast.** This chapter describes how Navigant estimated the energy efficiency potential under a number of different scenarios, accounting for realistic market adoption rates that consider consumer behaviour and decision-making and quantify the program costs of delivering this potential. Four achievable potential scenarios were analyzed:
    - *Scenario A:* constrained (assuming a program cost or incentive constraint)
    - *Scenario B:* maximum achievable (assuming no program cost or incentive constraints, and an "ideal" program design)
    - *Scenario C:* a semi-constrained scenario that differed for each fuel (assuming an average incentive level for electricity, and assuming achievement of a greenhouse gas emissions target for natural gas)
    - *Scenario D:* an electricity-only demand-based scenario
- **Whole Building Analysis.** This chapter describes how Navigant developed, for a single commercial segment, a "top-down" econometric forecast of energy efficiency potential to compare to the more traditional "bottom-up" measure-based modelling outputs. This task also identified

opportunities to use actual historic building-level consumption data to inform achievable potential modelling in the future.

- **Sensitivity Analysis.** This chapter describes how Navigant quantified the approximate uncertainty associated with estimated potential by testing the sensitivity of outputs to changes in key modelling parameters.
- **Findings and Recommendations.** This chapter highlights Navigant's key findings drawn from the analysis and lays out a series of recommendations for the development of future achievable potential studies.

2. BASE YEAR DISAGGREGATION

The objective of the base year disaggregation (BYD) task was to establish a detailed profile of electricity and natural gas consumption in Ontario across all regions, sectors, segments,[6] and end uses for the 2017 base year. Disaggregation helps illustrate how energy use and energy efficiency potential varies by housing or business type (i.e., segments) as well as by technology type (i.e., end use); this can be useful for targeting energy efficiency program design and implementation, among other applications. The disaggregated base year data, along with the Independent Electricity System Operator (IESO) and natural gas utilities' forecast energy consumption and building stock changes, are key inputs to the development of the reference forecast.

This chapter of the potential study report is divided into three sections:

1. **Scope:** Defines the geographic granularity of this potential study, as well as the sectors, segments, and end uses.
2. **Methodology:** Provides a high level description of Navigant's approach to disaggregating the electricity and natural gas consumption data provided by the IESO and the natural gas utilities into the required segments and end uses. Further detail is provided in Appendix A.
3. **Results:** Includes a summary of consumption, building stock (number of households and commercial floor space), and energy intensities derived as part of the BYD.

2.1 Scope

The base year used in this potential study is 2017. This was selected as the base year because 2017 was the last complete calendar year of available data at the time of potential study's inception.

Electricity and natural gas consumption were disaggregated into zones/natural gas regions, sectors, segments, and end uses, as illustrated in Figure 2-1.

Figure 2-1. Illustrative Breakdown of Base Year Disaggregation

Source: Navigant analysis

---

[6] Sometimes referred to in other studies as sub-sectors or building types, a segment defines a subset of buildings within a sector, defined either by physical characteristics of the building type (residential sector) or by the activities conducted there (commercial and industrial).

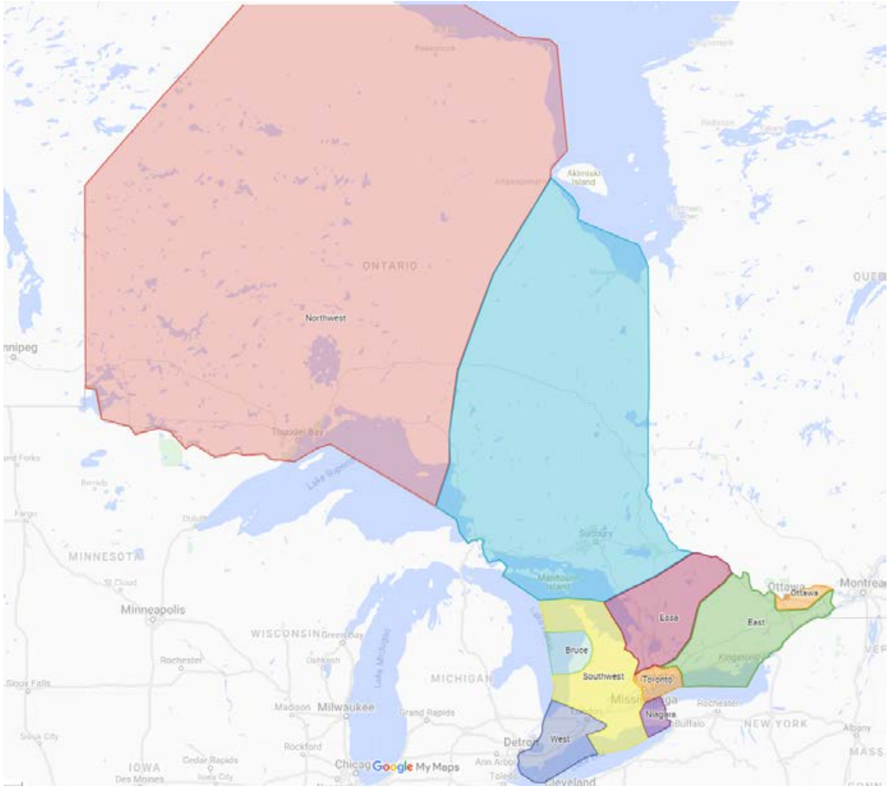
2.1.1 Regional

The IESO provided 2017 electricity consumption data for each IESO zone, broken down by IESO end use and segment. The IESO also provided a count of households and commercial floor space by IESO zone and segment (shown in Appendix A.1).

The natural gas utilities (Enbridge Gas Distribution and Union Gas[7]) each provided Navigant with a count of customers and 2017 natural gas consumption by segment and natural gas region.[8] The natural gas utilities were able to also break the consumption data out by IESO zone. However, a portion of the consumption data was provided only at the provincial level due to customer confidentiality limitations. Navigant allocated this consumption to the IESO zones using a set of approaches specific to the sector in question (see Section 2.2 and Appendix A.2 for more detail).

Receiving natural gas consumption data, broken out by both IESO zone and natural gas region, allowed Navigant to map the five natural gas utility regions to the 10 IESO zones, ensuring results can be presented using both sets of geographic boundaries. IESO zones and natural gas utility regions are shown in Figure 2-2. The natural gas regions used in this potential study are defined in Appendix A.4.

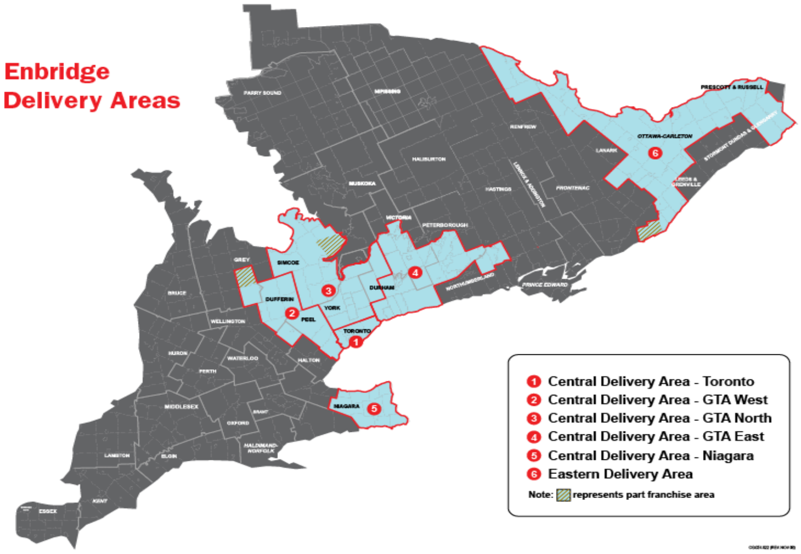
Figure 2-2. IESO Zones and Natural Gas Utility Regions



---

[7] Enbridge Gas Distribution Inc. and Union Gas Limited merged on January 1, 2019 to form Enbridge Gas Inc. Enbridge Gas Inc. provided data for each former utility's service areas to Navigant separately with unique characteristics requiring distinct steps for disaggregation. For this reason, the two entities have been described separately throughout this document.

[8] In some cases, the utilities' data protection rules prohibited them from sharing segment-level consumption by zone or region—for example, in such cases as where the number of customers in a segment is sufficiently small that geographic specificity could result in the release of commercially sensitive information.



Source: IESO and OEB[9]

2.1.2 Sector

Both the IESO and natural gas utilities provided consumption data broken out by sector (residential, commercial, and industrial).

---

[9] http://www.ieso.ca/localContent/zonal.map/index.html, https://www.enbridge.com/

2.1.3 Segments

For this potential study, each sector is further subdivided into segments, which are summarised in Table 2-1. Navigant reviewed prior electric and natural gas potential studies in Ontario, leveraged recent experience conducting potential studies in other Canadian provinces, and consulted with relevant stakeholders to develop this segment list. The 2019 potential study BYD includes six residential, 16 commercial, and 13 industrial segments.[10]

Table 2-1. Segments by Sector

Residential	Commercial	Industrial
Detached House	Large Hotel	Chemicals Manufacturing
Attached / Row House	Other Hotel/Motel	Fabricated Metals Manufacturing
Multi-Res High Rise	Large Office	Food and Beverage Manufacturing
Multi-Res Low Rise	Other Office	Mining, Quarrying and Oil & Gas Extraction
Low Income, Single-family	Large Non-Food Retail	Transportation and Machinery Manufacturing
Low Income, Multifamily	Other Non-Food Retail	Nonmetallic Minerals Product Manufacturing
	Food Retail	Pulp, Paper and Wood Products Manufacturing
	Hospital	Petroleum Manufacturing
	Long-Term Care	Plastic and Rubber Manufacturing
	Restaurant	Primary Metals Manufacturing
	School	Agriculture
	University/College	Water & Wastewater Treatment
	Warehouse	Other Industrial
	Other Commercial	
	Data Centre[11]	
	Street Lighting	

Source: Navigant analysis

2.1.4 End Uses

Table 2-2 outlines the end uses defined for each sector. Navigant reviewed prior electric and natural gas potential studies in Ontario, leveraged recent experience conducting potential studies in other Canadian provinces, and consulted with relevant stakeholders to develop the full list of end uses. Navigant's BYD includes 10 residential, 10 commercial, and 10 industrial end uses.

---

[10] Descriptions and examples are provided for each of the industrial segments in Appendix A.2.3.

[11] Data Centre and Street Lighting are only included as segments in electric workbooks.

Table 2-2. End Uses by Sector

Residential	Commercial	Industrial
Space Heating	Space Heating	**Compressed Air**
Space Cooling	**Computer Equipment**	**Lighting**
Ventilation and Circulation	Cooking	**Motors – Fans/Blowers**
Lighting	**Space Cooling**	**Motors – Pumps**
Water Heating	Water Heating	**Motors – Other**
Washing/Drying Appliances	Misc. Commercial	**Process Cooling**
Cooking	**Ventilation and Circulation**	HVAC
Refrigeration	**Lighting**	Process Heating (Direct)
Other Plug Load	**Other Plug Load**	Process Heating (Water/Steam)[12]
Misc. Residential	**Refrigeration**	Other Process

Bolded end uses apply only to electricity; the remaining end uses apply to both.
Source: Navigant analysis

2.2 Methodology

This section provides a high level overview of the key steps taken in the disaggregation of the residential, commercial, and industrial sectors. A detailed methodology and list of data sources used throughout the disaggregation task are provided in Appendix A.1. For all sectors, base year consumption was provided by the IESO (for electricity) and the natural gas utilities (for natural gas). In some cases, Navigant had to re-categorise the energy consumption data for some customer groups to ensure alignment with the sectors of this potential study. For example: bulk-billed multi-residential buildings are considered part of the commercial sector in the natural gas utilities' data but are considered residential for the purposes of this potential study.

2.2.1 Residential Methodology

The IESO provided Navigant with residential electricity consumption broken out by IESO zone, segment, and end use. The segments and end uses included in the data provided by the IESO's planning team are generally consistent with those used for the 2019 potential study with a few exceptions. Within the residential sector, the IESO does not break out low income residential segments (i.e., low income single-family and low income multifamily) in their typical business and planning activities; however, the Project Team, based on input from stakeholders, directed Navigant to create these new segments for the potential study to capture these customers' unique consumption profiles and programmatic needs. The IESO provided Navigant with counts of low income versus non-low income households by IESO zone based on Statistics Canada data, which Navigant used to map consumption and housing stock into the segments listed in Section 2.1.3.[13] The IESO also provided an estimate of the number of households in the base year, broken out by IESO zone and segments.

The natural gas utilities provided Navigant with base year natural gas consumption. Consumption data was not provided split out by end use, as data at this level was not available. Consumption data was mapped to the natural gas regions and partially mapped to IESO zones. Unallocated consumption (i.e.,

---

[12] Given the very small volume of electricity consumption for this end use, process heating by electricity associated with water and steam is included within the Other Process end use for the base year.

[13] Low income definition is based on Save on Energy Home Assistance Program eligibility: https://www.saveonenergy.ca/en/For-Your-Home/Low-Income-Help

consumption for which no zone was provided) was mapped to all 10 IESO zones proportionally, based on already allocated natural gas consumption. Sector-level splits of natural gas consumption data provided by the natural gas utilities were determined by sector rather than customer type. For consistency with the electricity analysis, bulk-billed multi-residential building consumption was transferred from the commercial to the residential sector.

Navigant used the IESO's Residential End Use Survey (REUS)[14] to develop an estimate of natural gas-connected households by IESO zone. These values were applied to IESO-provided household counts to determine the number of natural gas-connected households per zone. Natural gas utilities provided the number of customer connections by IESO zone; however, issues related to segment mapping (e.g., number of customers is not always the same as number of households) led Navigant to use a combination of the REUS data and IESO household estimates to determine the number of natural gas-connected households. Navigant determined the percentage of low-income gas customers by applying the gas connected fuel share to the low-income electric stock. The low income end use intensity factors (EUI) from the 2016 Natural Gas Conservation Potential Study along with the gas low income stock data was used to calculate gas base year consumption data for the low income segments.

Navigant used the above information to develop end use intensity factors (EUIs) for each fuel/zone/segment/end use combination. EUIs represent the average annual consumption per household within a given segment and zone, for a given end use. Navigant made some adjustments to low income EUIs for several end uses (detailed in Appendix A.2.1) to reflect information captured by the REUS (i.e., higher electric heating and lower space cooling demands for these segments). EUIs were calibrated in the natural gas BYD to ensure calculated end use consumption aligned with segment consumption provided by the natural gas utilities.

2.2.2 Commercial Methodology

The IESO provided Navigant with commercial electricity consumption broken out by IESO zone, segment, and end use. The potential study segments match the segments used by the IESO's planning department with the exceptions outlined below. Data centres were split out from the other commercial electricity segment to capture their unique energy use and growing prevalence in the province. Data centres were not broken out of the other commercial segment for the natural gas commercial BYD due to the very low volume of natural gas consumed by this segment. The IESO also provided an estimate of all commercial floor space in the base year, broken out by segment and IESO zone, as well as a separate dataset estimating floor space for data centres broken out by IESO zone.

Navigant received base year natural gas consumption from the natural gas utilities. Consumption data was provided at the segment level because consumption at the end use level was not available. Consumption was also mapped to the natural gas regions and partially mapped to IESO zones. Unallocated consumption was mapped to IESO zones proportionally.

To determine natural gas-connected floor space, Navigant developed fuel shares by comparing customer counts provided by the natural gas utilities with the total number of commercial electricity consumers, determined from the 2017 Ontario Energy Board (OEB) Yearbook of Electricity Distributors (see Appendix B.2 for more details).

Navigant developed EUIs for each segment and end use using IESO end use consumption data for the electricity BYD and prior OEB achievable potential study data for the natural gas BYD. Navigant

---

[14] In the summer of 2018, the IESO conducted its first ever comprehensive Residential End Use Survey (REUS). The REUS provides valuable information about the building characteristics, equipment, appliances, and behaviours that drive residential energy use in Ontario. For more information about the REUS, visit the project's webpage: http://www.ieso.ca/en/Learn/Conservation-and-Energy-Efficiency/Home-Energy-Survey

developed EUIs for the data centre segment using third-party reports (detailed in Appendix B.2). Natural gas EUIs were calibrated to ensure calculated end use gas consumption aligned with gas utility-provided segment consumption.

2.2.3 Industrial Methodology

The IESO provided Navigant with industrial electricity consumption broken out by IESO zone, segment, and end use. The potential study segments largely mirror the segments used by the IESO's planning department. The only exception is that the IESO defines paper manufacturing and wood products as distinct segments, while these were combined for the potential study. Since industrial energy use is driven more by processes and production than by building floor space, the IESO does not develop industrial building stock forecasts nor does it disaggregate the agriculture and water and wastewater treatment segments by end use for its regular business and planning purposes; therefore, this information was not available.

To disaggregate the consumption for these segments (and the associated end uses), Navigant used multiple data sources, including reports provided by the IESO and the allocation factors developed for other Canadian potential studies. See Appendix A.1 for a full list of data sources.

For the natural gas BYD, the natural gas utilities provided consumption broken out by segment but not by end use because it was not available. Navigant consulted previous Canadian potential studies and another data source outlined in Appendix A.2.3 to develop end use allocation factors, which were used to disaggregate consumption from the segment level to the end use level.

2.3 Results

This section of the BYD chapter provides a set of summary outputs. For each sector, the following summary outputs are provided:

- Energy consumption by segment
- Energy consumption by IESO zone (electricity) or natural gas utility region (natural gas)
- Energy consumption by end use

Further summary outputs are provided in Appendix A.3.

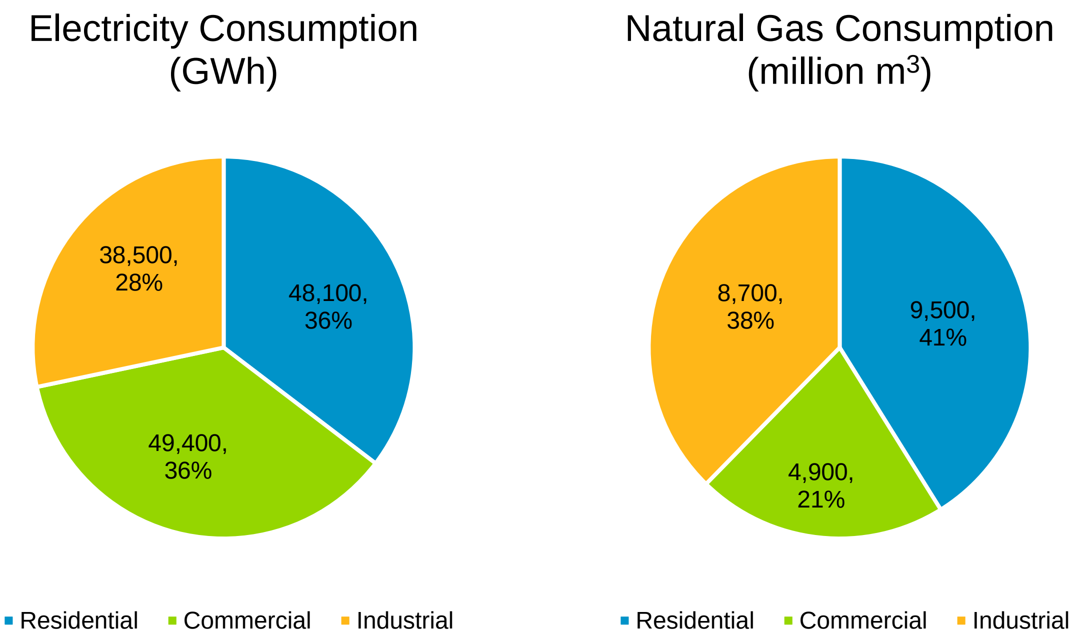
This section is divided into four sections:

1. Provincial Results
2. Residential Results
3. Commercial Results
4. Industrial Results

2.3.1 Provincial Results

A summary of consumption in the base year for both fuel types (electricity and natural gas) is shown in Figure 2-3.

Figure 2-3. Total Consumption by Fuel Type



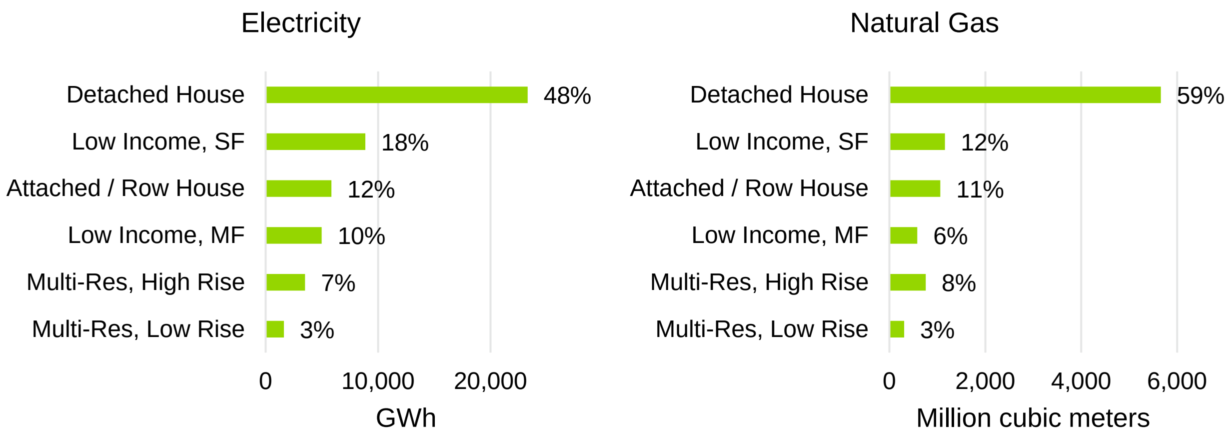
Source: Navigant analysis

The share of energy consumed by each sector varies between the two fuel types. The commercial sector makes up the largest portion of consumption (36%) for electricity and the smallest portion of consumption (21%) for natural gas. This is due to the high consumption from electricity intensive end uses (e.g., lighting) in the commercial sector relative to the high consumption of natural gas intensive end uses in the residential and industrial sectors (e.g., space heating and process heating, respectively). The residential sector has less variance; it makes up 36% of electricity consumption and 41% of natural gas consumption. Likewise, the industrial sector makes up 28% of electricity consumption and 38% of natural gas consumption.

2.3.2 Residential Results

Figure 2-4 shows the distribution of residential energy use by fuel type across the six residential segments.

Figure 2-4. Residential Electricity and Natural Gas Consumption by Segment, Province



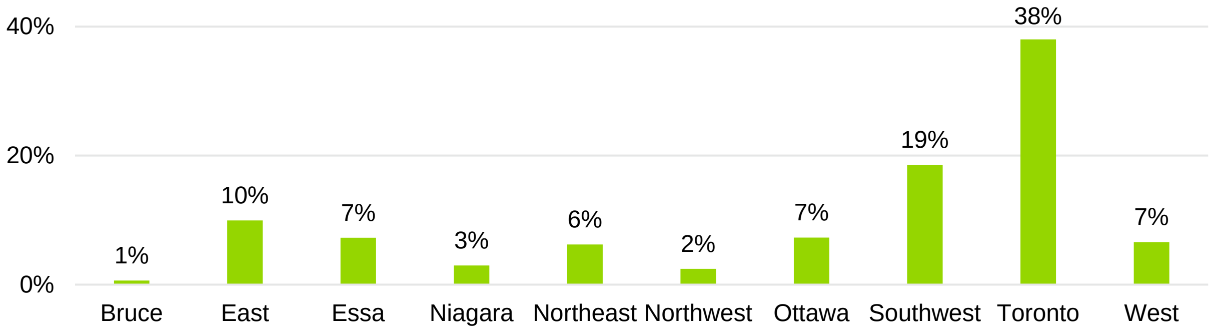
Source: Navigant analysis

For both fuel types, consumption is dominated by the detached house segment, which makes up 48% of electricity consumption and 59% of natural gas consumption. The low income, single-family segment (which includes both detached and attached/row housing) accounts for the second-largest consumption for both fuel types but accounts for a larger percentage of total consumption for electricity (18% for electricity vs. 12% for natural gas).

The low income, multifamily segment has the largest difference in segment-level contributions to provincial consumption between the two fuel types, accounting for only 6% of natural gas consumption as compared to 10% of electricity consumption. This difference is driven by survey findings drawn from the IESO's REUS that indicate the primary space heating equipment of low income households is more likely (than non-low income households) to be fuelled by electricity.

Figure 2-5 shows the distribution of residential electricity by IESO zone.

Figure 2-5. Residential Electricity Consumption by IESO Zone

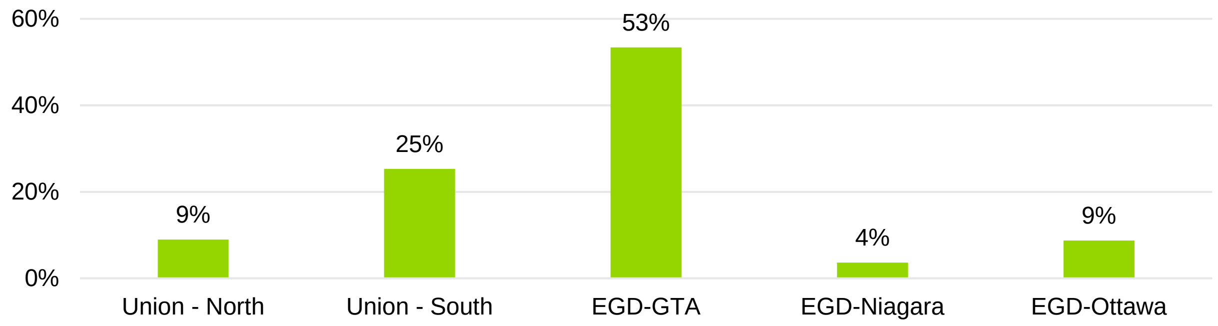


Source: Navigant analysis

Electricity consumption across IESO zones is largely driven by housing stock. IESO zones with large metropolitan centres (e.g., Toronto, Southwest) account for over 50% of total consumption, while IESO zones with less housing (e.g., Bruce, Northwest) consume less energy by comparison.

Figure 2-6 shows natural gas consumption by natural gas region.

Figure 2-6. Residential Natural Gas Consumption by Natural Gas Region



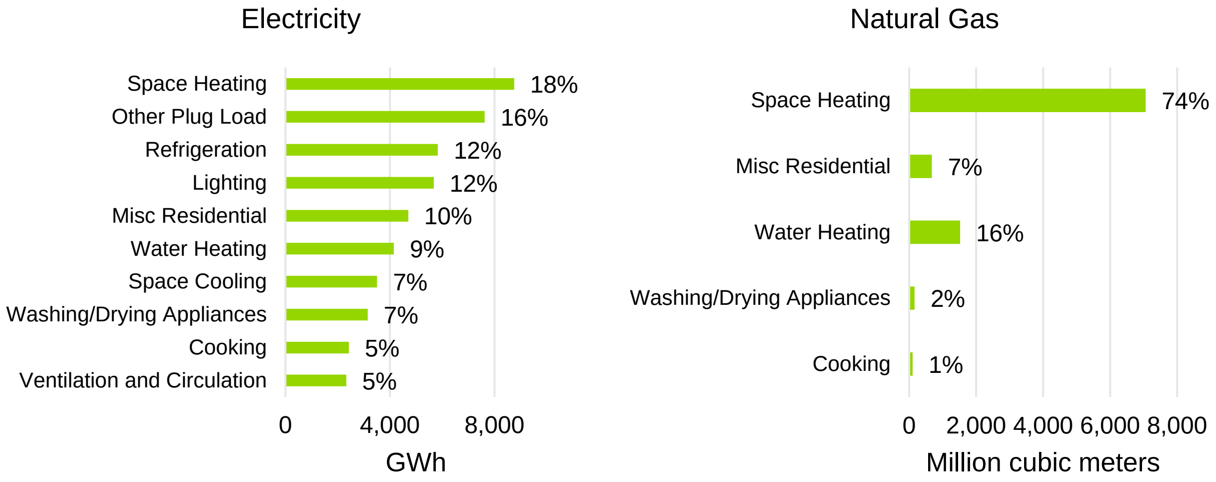
EGD = Enbridge

Source: Navigant analysis

Union accounts for 35% of residential natural gas consumption in the base year and Enbridge accounts for the remaining 65%. The Enbridge – GTA region accounts for 53% of total residential natural gas consumption. Consumption by natural gas region is not totally proportional to housing stock but tends to be skewed to regions (the GTA and southwestern Ontario, for example) with greater access to natural gas.

Figure 2-7 shows residential energy consumption by end use.

Figure 2-7. Residential Electricity and Natural Gas Consumption by End Use, Province



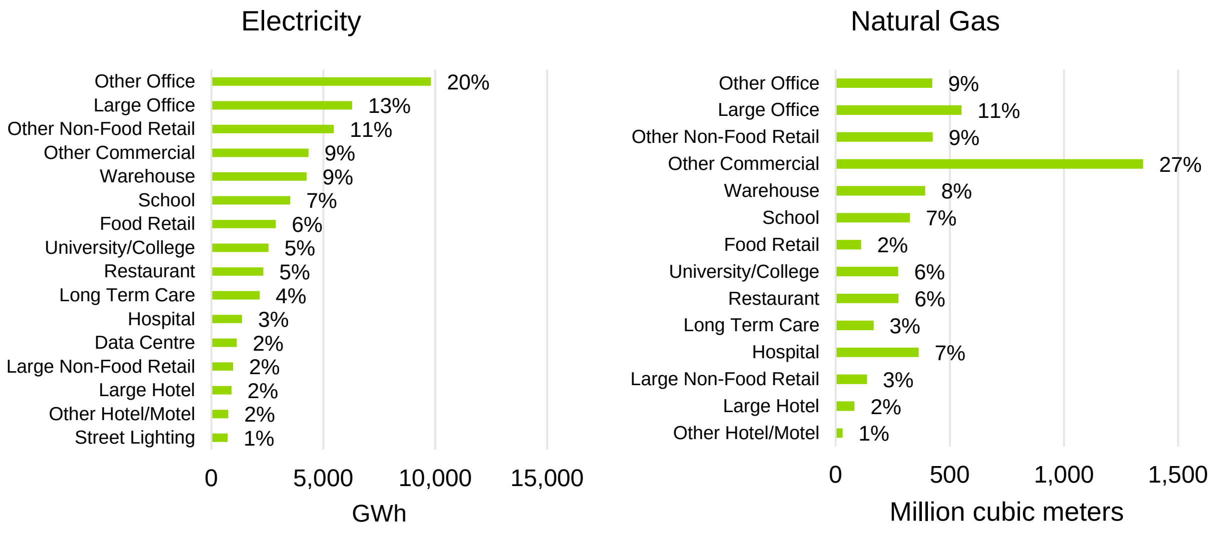
Source: Navigant analysis

Space heating accounts for the greatest consumption across both fuel types, accounting for 18% of electricity consumption and 74% of natural gas consumption.

2.3.3 Commercial Results

Figure 2-8 shows the distribution of commercial energy use by fuel type.

Figure 2-8. Commercial Natural Gas and Electricity Consumption by Segment, Province



Source: Navigant analysis

Electricity consumption is led by the other office segment, which accounts for 20% of total electricity consumption in the base year. Other high consumption segments include large office (13%), other non-food retail (11%), and other commercial (9%). Office segments tend to lead commercial electric consumption due to their large lighting loads—an end use that is not applicable to the natural gas fuel type.

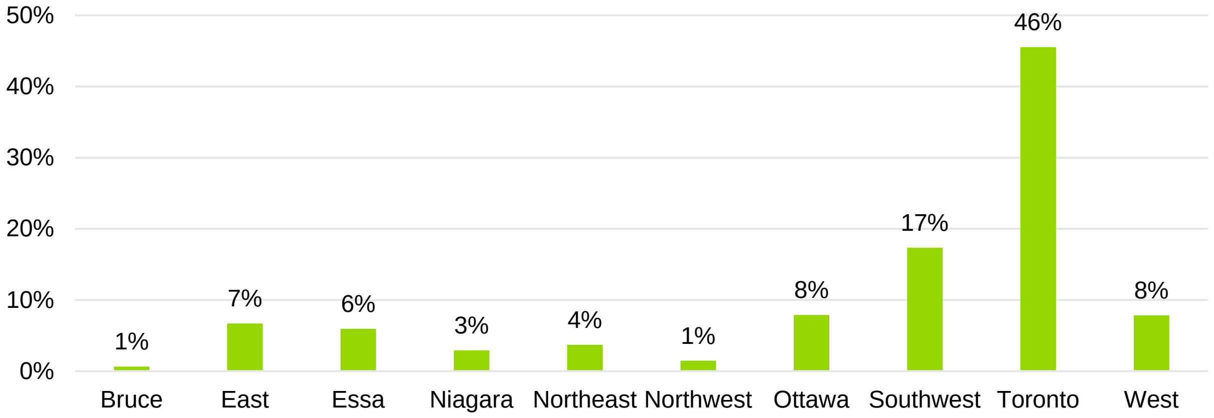
Natural gas consumption is led by the other commercial segment,[15] which accounts for 27% of total natural gas consumption in the base year. Other high consumption natural gas segments include large office (11%), other non-food retail (9%), and other office (9%).

---

[15] The other commercial segment includes a wide variety of building types that do not fit into the other categories, including: arenas and auditoria, day cares, gas stations, laundromats, churches, performance venues, correctional and psychiatric facilities, and public park buildings.

Figure 2-9 shows the distribution of provincial commercial sector electricity consumption by IESO zone.

Figure 2-9. Commercial Electricity Consumption by IESO Zone

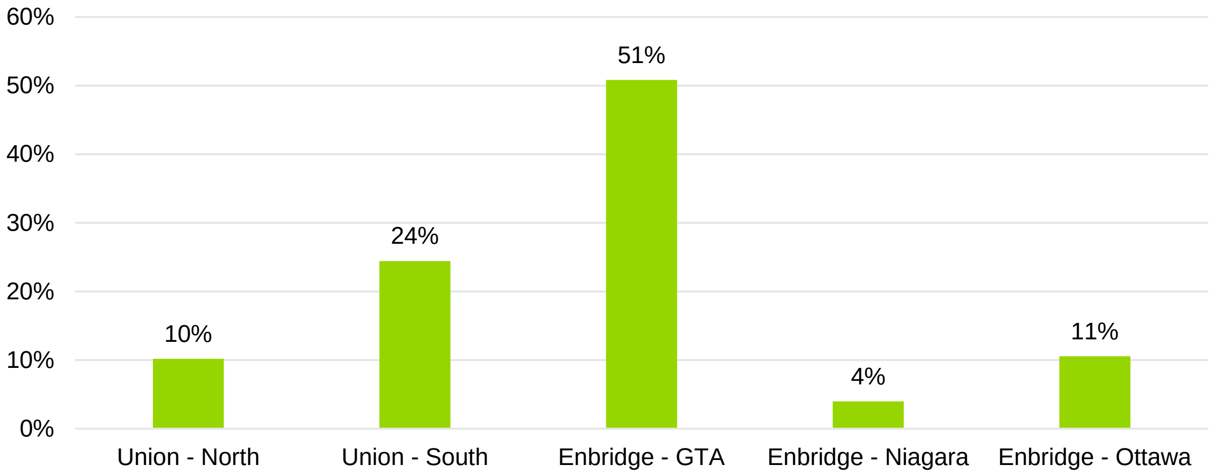


Source: Navigant analysis

IESO zones with large populations or with large metropolitan centres account for most of the consumption.

Figure 2-10 shows the distribution of provincial natural gas consumption across the five natural gas utility regions.

Figure 2-10. Commercial Natural Gas Consumption by Natural Gas Region

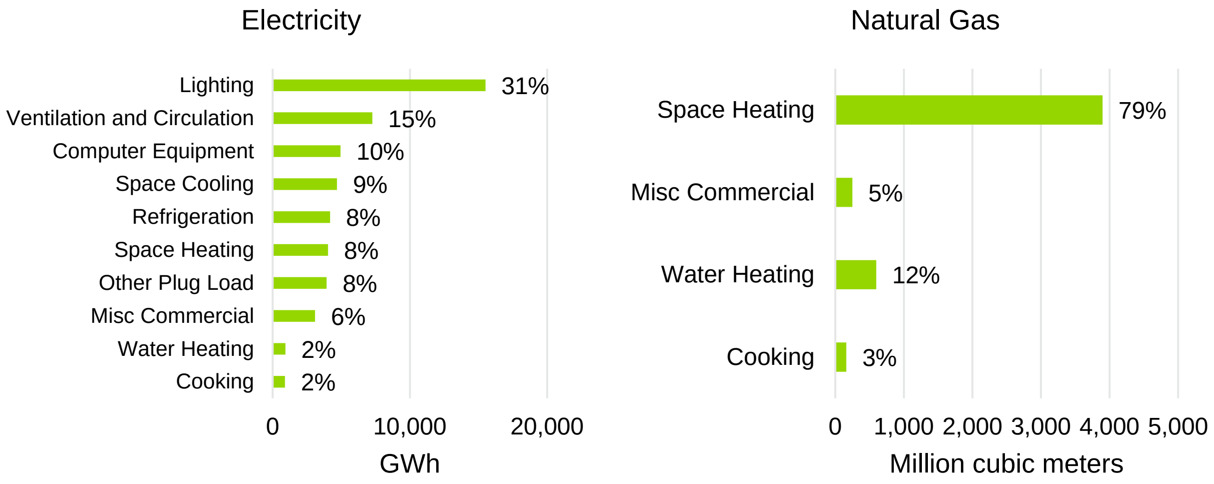


Source: Navigant analysis

Union accounts for 34% of commercial natural gas consumption in the base year and Enbridge accounts for the remaining 66%. The Enbridge – GTA region accounts for 51% of total commercial natural gas consumption.

Consumption by natural gas region is not fully proportional to commercial floor space, as natural gas consumption is higher in regions with greater access to natural gas infrastructure.

Figure 2-11. Commercial Consumption by End Use, Province



Source: Navigant analysis

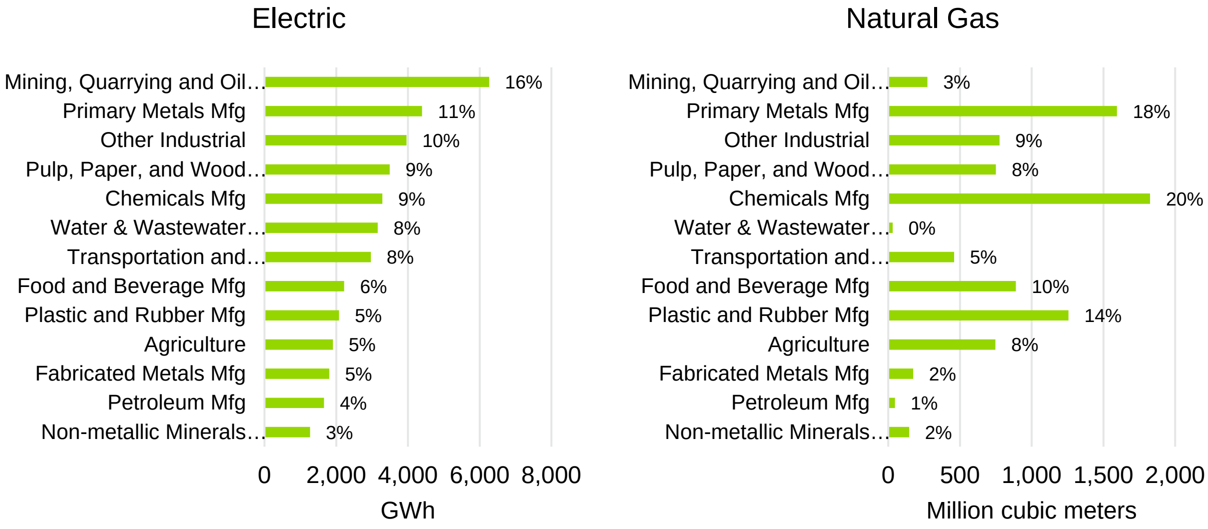
Lighting accounts for 31% of electricity consumption in the base year and accounts for the most electricity consumption of any end use.

As in the residential sector, natural gas consumption is led by space heating, which accounts for 79% of natural gas consumption. A key difference between the residential electricity and natural gas sectors is that in the residential sector space heating is the largest end use for both fuels, while in the commercial sector, space heating represents a much smaller proportion of overall consumption.

2.3.4 Industrial Results

Figure 2-12 shows the distribution of industrial energy use by fuel type across all the different industrial segments.

Figure 2-12. Industrial Consumption by Segment, Province



Source: Navigant analysis

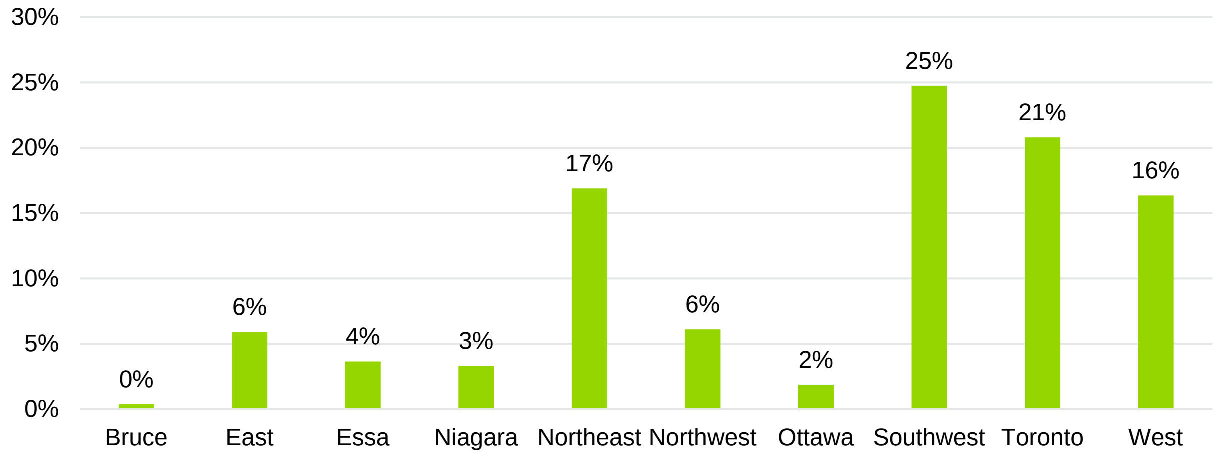
These charts do not include natural gas use for power generation.

Electricity consumption is led by the mining, quarrying, and oil & gas extraction segment, with 16% of total consumption, followed by primary metals manufacturing (11%) and other industrial (10%).

Natural gas consumption is led by the chemicals manufacturing segment, with 20% of total consumption, followed by primary metals manufacturing (18%) and plastic and rubber manufacturing (14%).

Figure 2-13 shows the distribution of industrial electricity consumption by IESO zone.

Figure 2-13. Industrial Electricity Consumption by IESO Zone

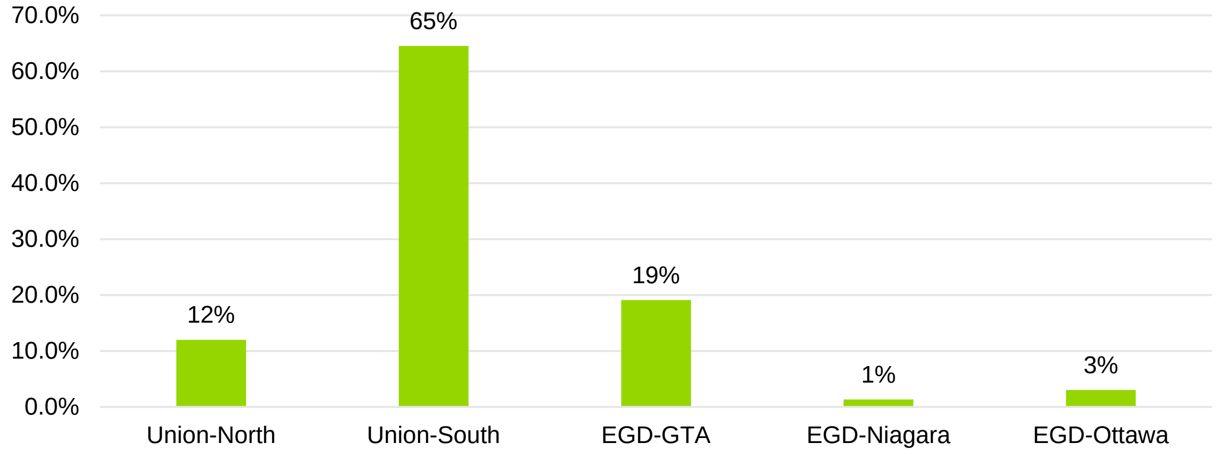


Source: Navigant analysis

The geographic distribution of electricity consumption in the industrial sector is much flatter than for the commercial or residential sectors. This geographic distribution is not driven as much by population as the residential and commercial sectors. Rather, the driving factor is proximity to production inputs. For example, the Northeast IESO zone accounts for only 6% of residential electricity consumption but nearly 20% of industrial electricity consumption.

Figure 2-14 shows natural gas consumption by natural gas region.

Figure 2-14. Industrial Natural Gas Consumption by Natural Gas Region

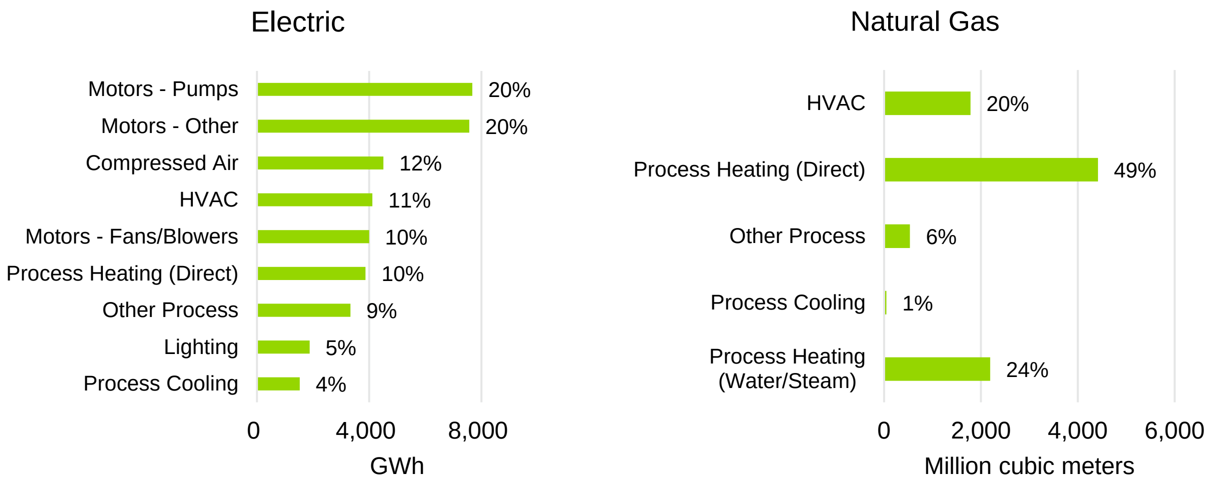


EGD = Enbridge
Source: Navigant analysis

Union accounts for 77% of total industrial consumption in the base year, and Enbridge accounts for 23%. The Union – South region accounts for 65% of total industrial natural gas consumption. A significant amount of Ontario's manufacturing industry is concentrated in Southern Ontario, explaining the high consumption in Union – South and Enbridge GTA.

Figure 2-15 shows industrial energy consumption by end use.

Figure 2-15. Industrial Natural Gas and Electricity Consumption by End Use, Province



Source: Navigant analysis

Motors account for most industrial electricity consumption in the base year, with motors – pumps consuming 20% of total electricity consumption, motors – other consuming 20%, and motors – fans/blowers consuming 10%.

Natural gas consumption in the base year is highest for the process heating (direct) end use, which accounts for 49% of total natural gas consumption. Process heating (water/steam) accounted for 24% of consumption, followed by HVAC, which accounted for 20% of consumption.

These results, and those provided in above for the other sectors, are direct inputs for the reference forecast (described in the next chapter).[16] This disaggregation provides the values (e.g., EUIs) and approaches (e.g., with respect to segment disaggregation) required to disaggregate the input forecast provided by the IESO and the natural gas utilities to the level of granularity required for this potential study.

---

[16] Tabular versions of all of the graphics presented above (and below) may be found in the Base Year Disaggregation Excel Appendix.

3. REFERENCE FORECAST

The objective of the reference forecast task is to provide a 20-year forecast of electricity and natural gas consumption by sector, segment, and end use. This task builds off the outputs of the BYD in conjunction with the input electricity and natural gas consumption forecasts provided by the IESO and the natural gas utilities. The goal of this task is to deliver a reference forecast of consumption of both fuels from 2018 through 2038 by IESO zone and natural gas region. The reference forecast is one of the key inputs required to develop projections of technical, economic, and achievable potential.

This chapter of the report is divided into three sections:

1. **Scope:** Describes the role of the forecast in calculating potential, the reference forecast period and the key requirements and outputs.
2. **Methodology:** Provides a high level overview of Navigant's approach to developing the reference forecast for electricity and natural gas, respectively.
3. **Results:** Provides a summary of forecast consumption, building stock, and energy intensities.

3.1 Scope

This achievable potential study considers the 20-year period from 2019 through to the end of 2038. Developing estimated technical, economic, and achievable potential projections requires a reference forecast to help calibrate and scale those projections. Navigant's task was not to generate a forecast, but to take forecasts provided by the IESO and natural gas utility forecasting groups (the *input* forecasts), adjust them as appropriate, and disaggregate them to the level of granularity required by the potential study (the *output* forecasts). This task's output, the reference forecast, had several key requirements:

- **The input forecasts must be compatible.** Differences in how the electricity and natural gas input forecasts are developed are inevitable. For use in an integrated potential study, however, the forecasts must present a reasonably consistent view of the future (e.g., in terms of economic growth).[17] Key factors include:
    - **The input forecasts of electricity and natural gas consumption must exclude any forecast programmatic Conservation and Demand Management (CDM)/Demand Side Management (DSM) achievement.** The reference forecast must not include the effects of any future IESO or natural gas utility energy efficiency programs.
    - **The input forecasts must include the persistence of historical programmatic savings, the impacts of codes and standards, and the effects of natural efficiency.** These effects must be included in the reference forecast to ensure that projected potential values are all attributable to new programs only and are net of free riders.
- **The output forecasts must be disaggregated by fuel type, zone/region, sector, segment, and end use.** The granularity of the output reference forecast is driven by that defined for the BYD.

---

[17] Navigant's scope of work allowed for the possibility that the input forecasts were not compatible, with a defined strategy for addressing such a contingency.

Navigant has not altered the top line forecasts provided by the IESO and the natural gas utilities as part of this task.[18] This ensures that the forecasts used for this potential study are consistent with those used by the contributing agencies for planning purposes. As with the BYD, Navigant's adjustments to the input forecasts are applied *only* below the top line forecasts.[19]

3.2 Methodology

This section provides a high level overview of the key steps taken to:

- Verify the compatibility of the input forecasts (including verifying that the input forecast components provided satisfied the requirements outlined in Section 2.1)
- Disaggregate the input electricity and natural gas forecasts to the level of granularity required for this potential study

A more detailed methodology and list of data sources used throughout the forecast are provided in Appendix B.

This section is divided into the following sub-sections:

- Compatibility Assessment
- Disaggregation Methodology
    - Residential Disaggregation Methodology
    - Commercial Disaggregation Methodology
    - Industrial Disaggregation Methodology

3.2.1 Compatibility Assessment

The goal of the compatibility analysis was to ensure that IESO and the natural gas utilities have a broadly consistent view of the future while acknowledging that they are:

- Forecasting the consumption of different commodities that have different end uses and hence use different forecasting approaches[20]
- That the geographic distribution of natural gas consumers is often quite different from that of electricity consumers

Given the different fuel types being forecast and the diversity in geographic service territories, differences in load forecast methodologies and their input assumptions are inevitable. Figure 3-1 presents a comparison of some of these differences.

Forecast compatibility does not mean that a perfect alignment exists in forecast assumptions. There is cause for concern only where the forecast assumptions used by the IESO and natural gas utilities

---

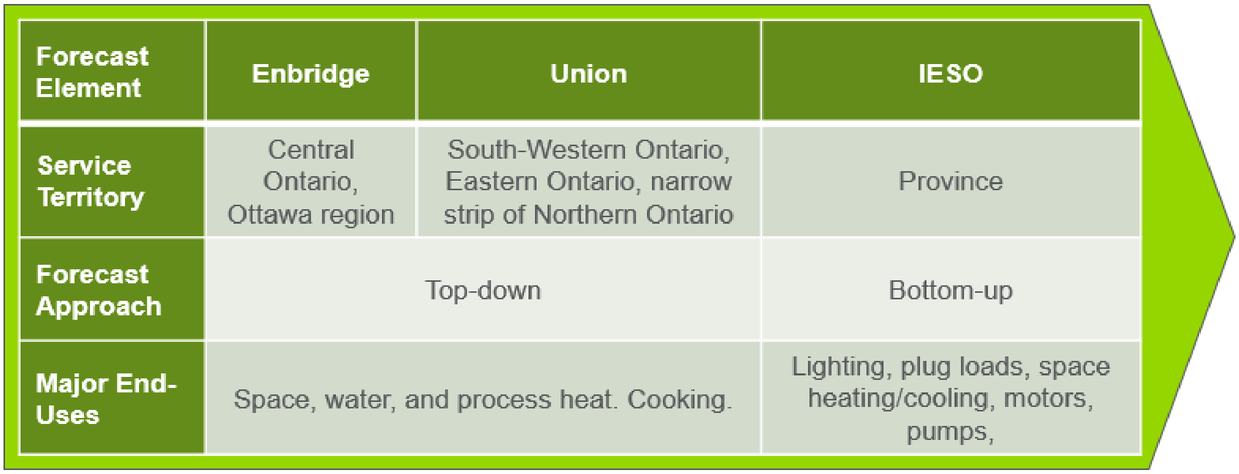
[18] Adjustments to the top line forecast would only be considered if there were notable concerns with forecast compatibility, e.g., having to adjust for the effects of CDM programs.

[19] The only exception to this is the need to extend the natural gas input forecast from 10 years (as provided in the input forecasts) to 20 years (as required for this potential study).

[20] The IESO uses a bottom-up end use forecasting model whereas the natural gas utilities use a top-down econometric model.

suggest a material disconnect between overall assumptions regarding the state of the province for the duration of the reference forecast period.

Figure 3-1. Challenges with Comparing Electricity and Natural Gas Forecasts



Forecast Element	Enbridge	Union	IESO
Service Territory	Central Ontario, Ottawa region	South-Western Ontario, Eastern Ontario, narrow strip of Northern Ontario	Province
Forecast Approach	Top-down		Bottom-up
Major End-Uses	Space, water, and process heat. Cooking.		Lighting, plug loads, space heating/cooling, motors, pumps,

Source: Navigant analysis

Navigant's compatibility analysis proceeded along two different levels:

1. **Global Drivers:** Those factors that impact all sectors and segments.
    - **Historical/New DSM and CDM:** All forecasts incorporate the persistence of historical energy efficiency programs but do not include the impacts of future programs. This is critical to ensure that the estimated potential is not understated.
    - **Codes and Standards:** All forecasts incorporate the impacts of existing codes and standards. This ensures that the estimated potential is not overstated by capturing savings that are attributed to codes and standards.
    - **Natural Conservation:** All forecasts include the impacts of natural conservation, which reflects the reduction in consumption due to consumers' own actions that are not influenced by CDM/DSM programs. Inclusion of this effect is important for ensuring that the estimated conservation potential is net of free riders.
    - **Carbon Pricing:** The IESO, Enbridge, and Union forecasts account for the effects of carbon pricing using different methodologies. . Based on discussions with the IESO and natural gas utility forecasting teams it was determined that the differences are minimal and are expected to have a negligible impact on the forecast natural gas consumption (i.e., indistinguishable from statistical noise).
    - **Weather Effects:** All forecasts are based on "normal" (1-in-2 year), not extreme (e.g., 1-in-30 year), weather.[21] Weather is a key driver for load and a peak forecast is expected to

---

[21] Forecasting energy consumption requires some assumed set of future weather. Forecasts may use normal weather – either historical average weather values, or historical weather values that, when applied to forecast model parameters deliver a median forecast level of consumption – or extreme weather. Extreme weather is either the most extreme historical weather observed in the specified look-back period or the historical weather that, when applied to forecast model parameters, delivers the highest forecast consumption.

be significantly higher than a normal weather forecast and can overstate conservation potential.[22]

  - **Fuel Switching:** All forecasts assume that there will be no significant departures from historical trends in fuel switching (e.g., from electricity to natural gas water heating in the residential sector) over the reference forecast period. This is especially important for an integrated potential study such as this.

2. **Sector-Specific Drivers:** Those factors that impact only the sector in question. The forecast annual growth rate assumptions for the following key sectoral drivers were compared and were found to be reasonably in line with each other:[23]
   - Residential households
   - Commercial floor space
   - Industrial output/GDP/customer growth

Based on the analysis described above, Navigant concluded that the forecasts were compatible. Table 3-1 shows a summary outcome of Navigant's compatibility analysis. Additional details regarding how Navigant came to this conclusion may be found in Appendix B.2.

Table 3-1. Summary of Compatibility Analysis

Forecast Element		Compatible?
Global Drivers	Historical/New DSM and CDM	✓
	Codes and Standards	✓
	Natural Conservation	✓
	Carbon Pricing	✓
	Weather Effects	✓
	Fuel Switching	✓
Sector-Specific Drivers	Households (RES)	✓
	Employment (COM)	✓
	GDP/Output & Consumer Information (IND)	✓

Source: Navigant analysis

3.2.2 Disaggregation Methodology

This section provides an overview of the steps taken by Navigant to prepare the potential study reference forecast for the residential, commercial, and industrial sectors. This section describes the data received by Navigant from the IESO (for electricity), the natural gas utilities (for natural gas), and other third-party

---

[22] Given the different fuel types and associated differences in forecasting methodologies, differences in weather normalisation approaches are to be expected. The key is to ensure that the forecasts are based on normal weather.

[23] Differences in forecast methodologies and assumptions are inevitable as mentioned above. The key here is to ensure that the key sectoral drivers are reasonably aligned in direction and magnitude. Additional detail can be found in Appendix **Error! Reference source not found.**

sources where applicable and explains how this data was used to develop the final residential forecast by the segments and end uses defined for this potential study.[24]

3.2.2.1 Residential Disaggregation Methodology

For the electricity forecast, the IESO provided Navigant with a forecast of residential electricity consumption by segment and end use for each zone for the entire reference forecast period (2018-2038). The IESO also provided a forecast count of residential households over the same period. As in the data received for the BYD task, neither forecast included low income segments (low income, single-family and low income, multifamily). For the BYD task, the IESO provided Navigant with an estimate of low income households by segment group (single-family vs. multifamily) and by IESO zone. Navigant assumed that these ratios would remain constant throughout the forecast period. Using these ratios, Navigant mapped the consumption and household forecast into the appropriate Navigant-defined segments.

For the natural gas forecast, the natural gas utilities provided Navigant with a forecast of residential natural gas consumption, at the sector level, from 2018 to 2028. The natural gas utilities were unable to provide forecasts through to 2038, as their planning teams only forecast consumption over a 10-year period. Navigant extrapolated these forecasts from 2029 to 2038 using the 10-year, 2018 to 2028, compound annual growth rate for each utility. To disaggregate these sector-level forecasts by segment, end use, and zone, Navigant multiplied the EUIs estimated as part of BYD task by the household stock forecast. Navigant used the household forecast provided by the IESO. To determine the share of natural gas-connected households, Navigant used the natural gas-connected ratios from the BYD task by segment and IESO zone. Navigant assumed that these ratios would be constant throughout the reference forecast period. Output values are calibrated to ensure that the disaggregated forecast matches the utility-provided sector-level forecast.

3.2.2.2 Commercial Disaggregation Methodology

For the electric forecast, the IESO provided Navigant with a forecast of commercial electricity consumption by segment and end use for each zone for the entire reference forecast period (2018-2038). Navigant re-mapped this consumption to fit the segments defined in the BYD task. The input forecast does not break out data centres as a separate segment. Consumption for this segment is included in the other commercial segment. Navigant subtracted consumption in the data centre segment from the other commercial segment by multiplying the EUIs from the base year with a forecast of data centre stock to calculate consumption.

For the natural gas forecast, the natural gas utilities provided Navigant with a forecast of commercial natural gas consumption, at the sector level, from 2018 to 2028. As with the residential forecast, no data was available beyond 2028, and the forecasts were extrapolated out to 2038 using the growth rate from 2019 to 2028. To disaggregate these sector-level forecasts by segment, end use, and zone, Navigant multiplied the calibrated EUIs from the base year with the stock forecast. To determine natural gas-connected stock, Navigant multiplied the stock forecast provided in the electricity forecast by the natural gas-connected ratios developed in the BYD task. Navigant assumed that these ratios would be constant throughout the forecast period. Output values were calibrated to ensure that the disaggregated forecast matches the utility-provided sector-level forecast.

---

[24] Given that an end use electricity forecast was provided by the IESO, the main effort undertaken by Navigant was to organise the forecast provided into the sectors and segments as defined for this potential study.

3.2.2.3 Industrial Disaggregation Methodology

For the electricity forecast, the IESO provided Navigant with a forecast of industrial electricity consumption by segment and end use for each zone for the entire reference forecast period (2018-2038). Navigant re-mapped this consumption into the segments defined in the BYD task. The water and wastewater treatment segment did not include an end use breakdown. To disaggregate that segment's consumption into the appropriate end uses, Navigant used the end use allocation factors (percent of segment consumption by end use) from the base year. A stock forecast (e.g., number of buildings or floor space) is not used for the industrial sector.

For the natural gas forecast, the natural gas utilities provided Navigant with a forecast of industrial natural gas consumption, at the sector level, from 2018 to 2028. Forecast consumption from 2022 through 2028 was extrapolated out to obtain a forecast from 2029 to 2038 (similar to the residential and commercial sectors) by calculating the individual compound growth rate for each utility. To disaggregate the sector-level forecast down to the segment and end use, Navigant developed allocation factors, segment/end use as a percentage of total annual sales, using the base year sales and held the allocation factors constant for the reference forecast period.[25]

3.3 Results

This section summarises the outputs of the reference forecast. For each sector, the following outputs are provided:

- Energy consumption by segment from 2018 to 2038
- Energy consumption by IESO zone (electricity) or natural gas utility region (natural gas) from 2018 to 2038
- Energy consumption by end use from 2018 to 2038

Additional outputs are provided in Appendix B.

This section is divided into four sub-sections:

1. Provincial Results
2. Residential Results
3. Commercial Results
4. Industrial Results

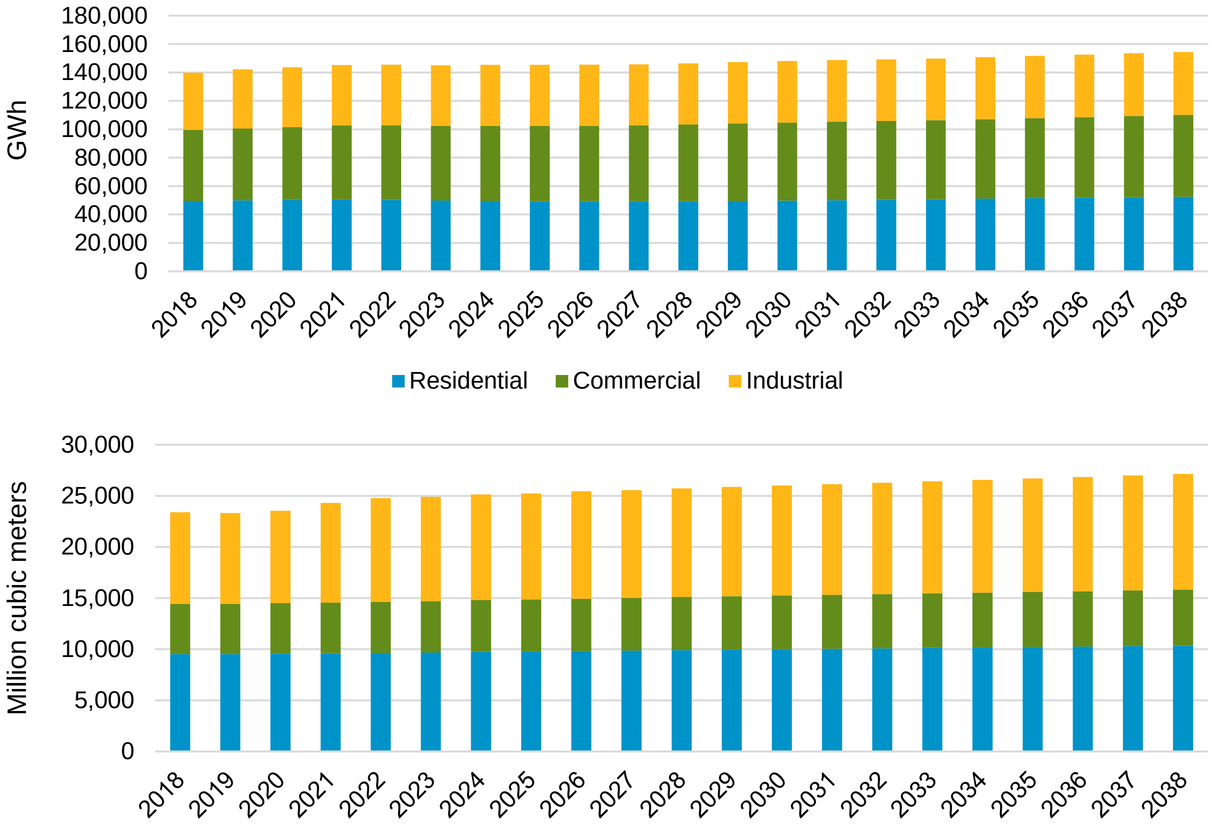
3.3.1 Provincial Results

This section provides a high level overview of results across all three sectors considered in the potential study. Figure 3-2 shows the total consumption in each sector throughout the entire reference forecast period for both fuel types.

---

[25] The allocation factors used for the industrial sector may are described in the base year disaggregation chapter.

Figure 3-2. Total Consumption by Sector and Year (Electricity and Natural Gas)



Sources: Navigant analysis, IESO, Enbridge Gas, Union Gas

Total provincial electricity consumption is forecast to increase from 139,800 GWh in 2018 to 154,400 GWh in 2038. Total provincial natural gas consumption is forecast to increase from 23,400 million cubic meters in 2018 to 27,100 million cubic meters in 2038. The key drivers for each sector will be discussed in the sub-sections that follow.

Figure 3-3. Electricity Sectoral Shares

Sources: Navigant analysis, IESO

Figure 3-4. Natural Gas Sectoral Shares

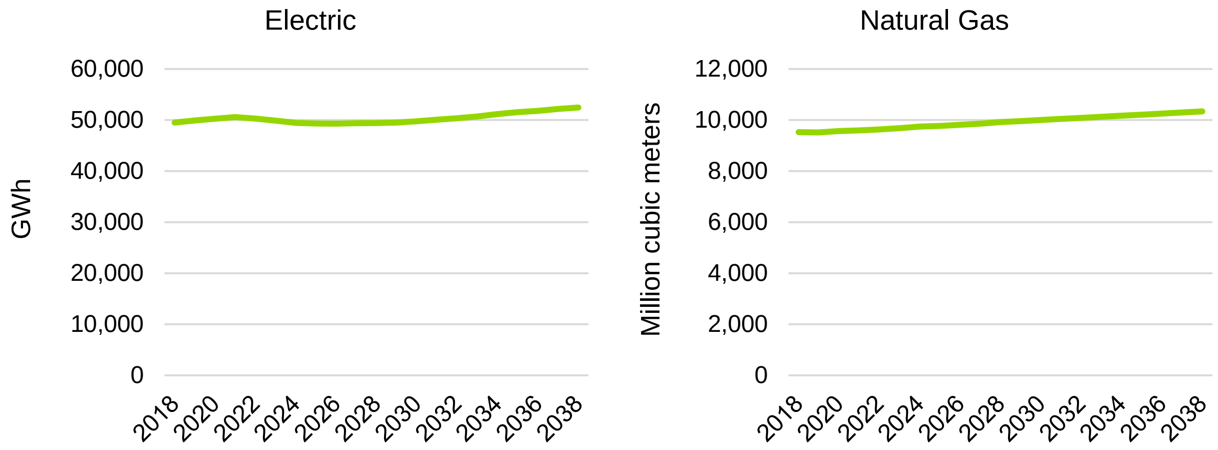
Sources: Navigant analysis, Enbridge Gas, Union Gas

Overall, the sectoral shares remain consistent for both fuels over the reference forecast period, as seen in Figure 3-3 and Figure 3-4. On the natural gas side, industrial consumption has seen a slight increase whereas residential consumption has seen a slight decrease.

3.3.2 Residential Results

For the residential sector, the electricity trends are driven by the IESO assumptions that underlie the end use forecast provided by segment and end use and their forecast of residential households. Navigant has mapped the IESO-defined segments and end uses to those defined for this potential study. Since an end use forecast was not available, the natural gas trends are driven by the total sectoral trend, the base year EUIs, and the household stock forecast.

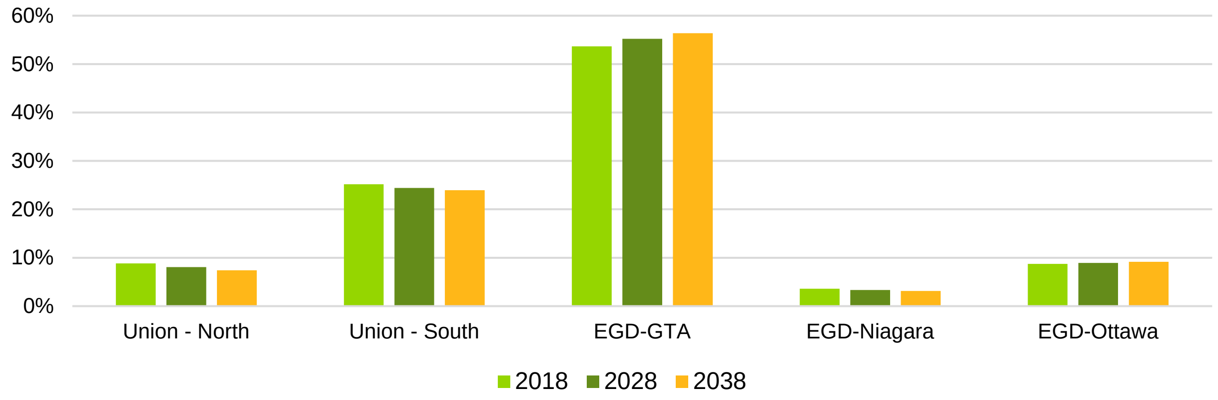
Figure 3-5. Total Residential Consumption by Year (Natural Gas and Electricity)



Sources: Navigant analysis, IESO, Enbridge Gas, Union Gas

Figure 3-5 shows the total consumption in the residential sector for both fuel types from 2018 to 2038. Total residential natural gas consumption increases from 9,500 million cubic meters in 2018 to 10,300 million cubic meters in 2038, increasing an average 0.4% per year. Total residential electricity consumption increases from 49,500 GWh in 2018 to 52,500 GWh in 2038, increasing an average 0.3% per year.

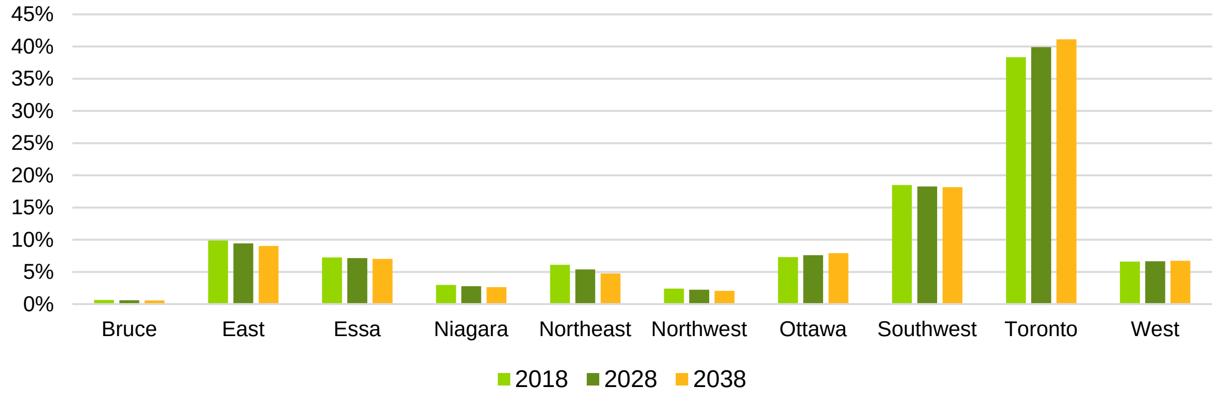
Figure 3-6. Residential Natural Gas Consumption by Year, by Natural Gas Region



EGD = Enbridge
Sources: Navigant analysis, Enbridge Gas, Union Gas

The distribution of residential natural gas consumption across the five natural gas regions does not vary significantly from 2018 to 2038. The percentage of sectoral consumption in the Union – South region decreases slightly from 2018 to 2038. Conversely, the EGD – GTA region increases slightly from 2018 to 2038. This change is primarily driven by an increase in population in large metropolitan centres – specifically the Greater Toronto Area, which lies in the EGD – GTA region.

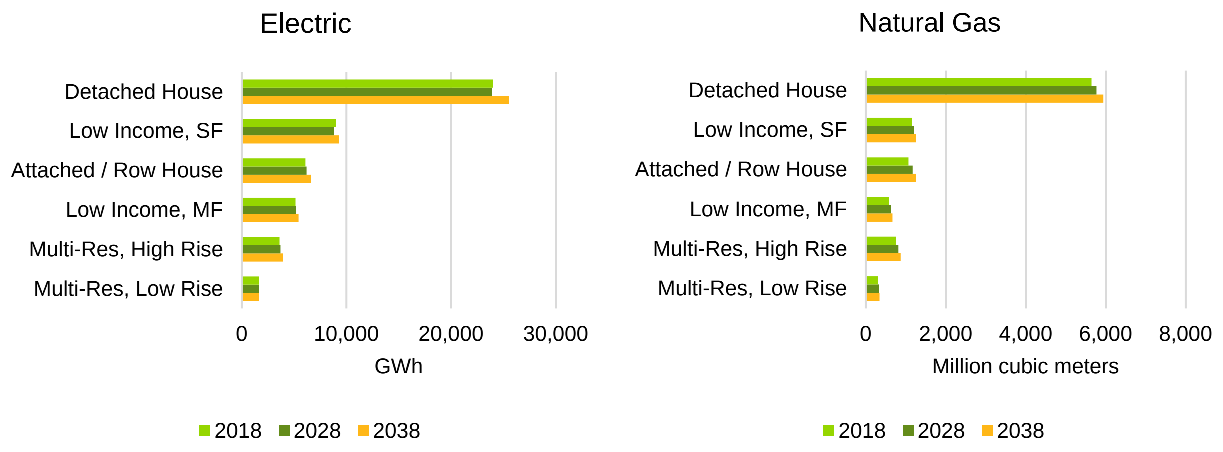
Figure 3-7. Residential Electricity Consumption by Year, by IESO Zone



Sources: Navigant analysis, IESO

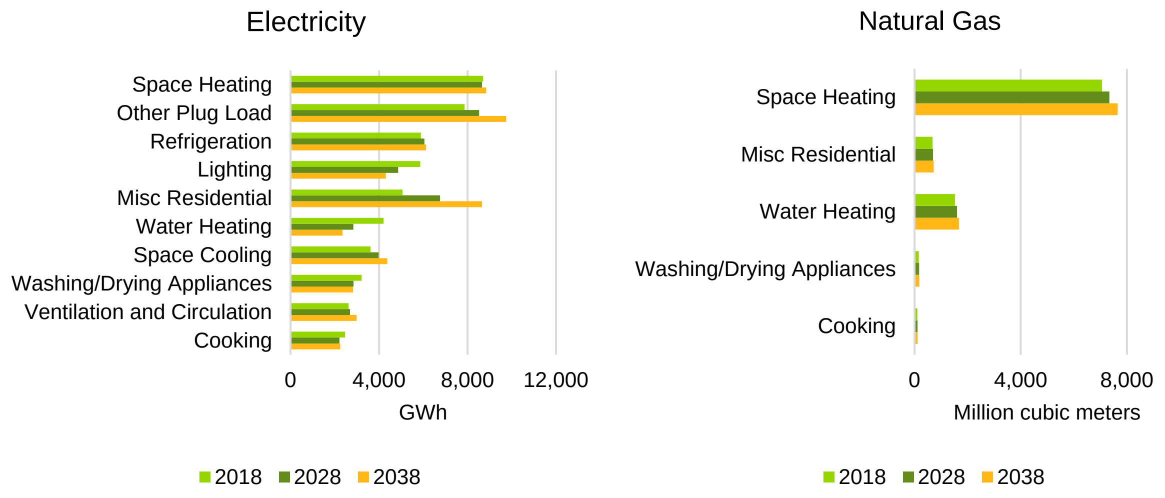
As with natural gas consumption, residential electricity consumption across the 10 IESO zones does not vary significantly from 2018 to 2038. The largest variance is seen in the Toronto zone, just as it is in the natural gas GTA zone.

Figure 3-8. Residential Consumption by Segment (Natural Gas and Electricity)



Sources: Navigant analysis, IESO, Enbridge Gas, Union Gas

Figure 3-9. Residential Consumption by End Use (Natural Gas and Electricity)



Sources: Navigant analysis, IESO, Enbridge Gas, Union Gas

Residential consumption by segment for both fuels is relatively stable over the reference forecast period. None of the segments decrease in consumption, for either fuel, over the reference forecast period except for electric water heating. This decrease is driven by fuel switching and efficiency gains.[26]

For electricity, the multi-res, high rise segment increases at the greatest rate. The miscellaneous residential and other plug load end uses see the largest growth across all the residential end uses. The multi-res, low rise segment decreases slightly over the forecast period. Unlike the multi-res high rise segment, in the multi-res low rise segment, the space heating end use sees a decrease in consumption over the forecast period.

---

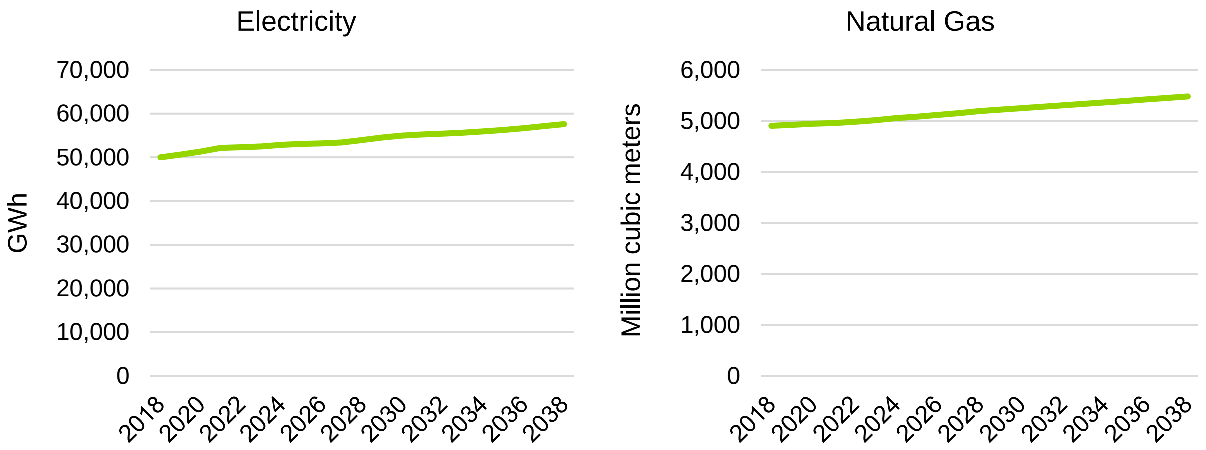
[26] The IESO Planning team shared its assumptions regarding fuel switching and efficiency gains to allow Navigant to make the appropriate adjustments to the natural gas water heating consumption reference forecast. Appendix B.2.1 discusses the fuel switching in some more detail.

For natural gas, the attached/row house segment sees the largest absolute growth. The consumption in this segment is largely composed of space heating and water heating, which see increased consumption over the forecast period. The detached house segment increases at the lowest rate. The miscellaneous residential end use makes up a much larger portion of consumption in the detached house segment than the attached/row house segment and sees little growth over the forecast period, thereby reducing the total growth observed in the detached house segment.

3.3.3 Commercial Results

Similar to the residential sector, the commercial electricity trends are driven by the IESO assumptions that underlie the end use forecast provided by segment and end use and their forecast of commercial floor space. Navigant has mapped the IESO-defined segments and end uses to those defined for this potential study. Like residential, an end use forecast was not available for natural gas. The natural gas trends are driven by the total sectoral trend, the base year EUIs, and the commercial floor space forecast. This is because the sectoral forecast was allocated down to the segment and end use level using the results from the BYD.

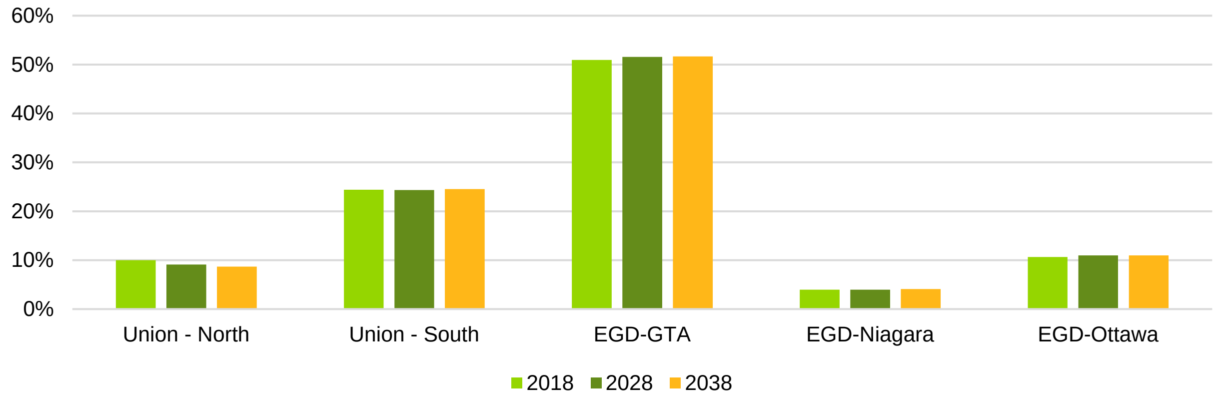
Figure 3-10. Total Commercial Consumption by Year (Natural Gas and Electricity)



Sources: Navigant analysis, IESO, Enbridge Gas, Union Gas

Figure 3-10 shows the total consumption in the commercial sector for both fuel types from 2018 to 2038. Total commercial natural gas consumption increases from 4,900 million cubic meters in 2018 to 5,500 million cubic meters in 2038, increasing an average 0.6% per year. Total commercial electricity consumption increases from 50,000 GWh in 2018 to 57,600 GWh in 2038, increasing an average 0.7% per year.

Figure 3-11. Commercial Natural Gas Consumption by Year, by Natural Gas Region

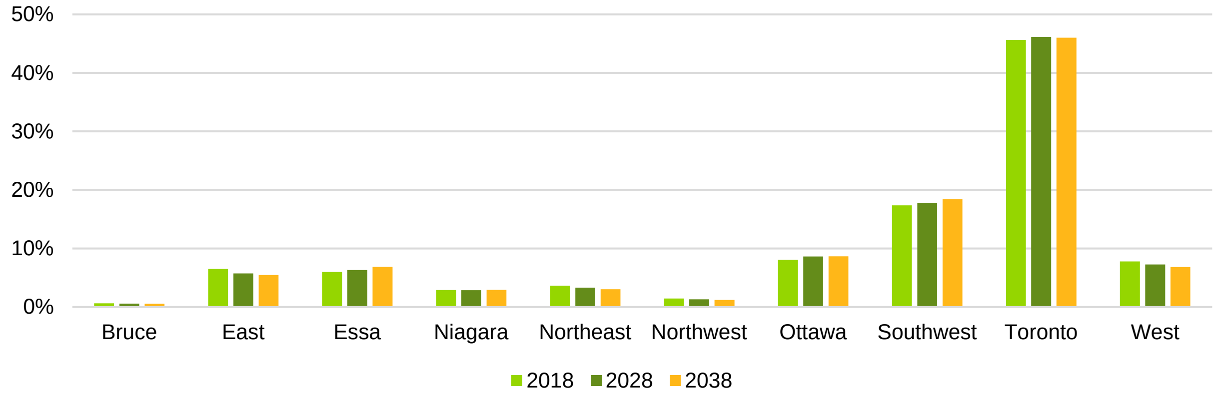


EGD = Enbridge

Sources: Navigant analysis, Enbridge Gas, Union Gas

The distribution of commercial natural gas consumption across the five natural gas regions does not vary significantly from 2018 to 2038. The difference in percent sectoral consumption does not shift significantly for any of the natural gas regions from 2018 to 2038. The EGD – GTA region experiences slight growth whereas the Union – North region decreases its share of sectoral consumption slightly over the reference forecast period.

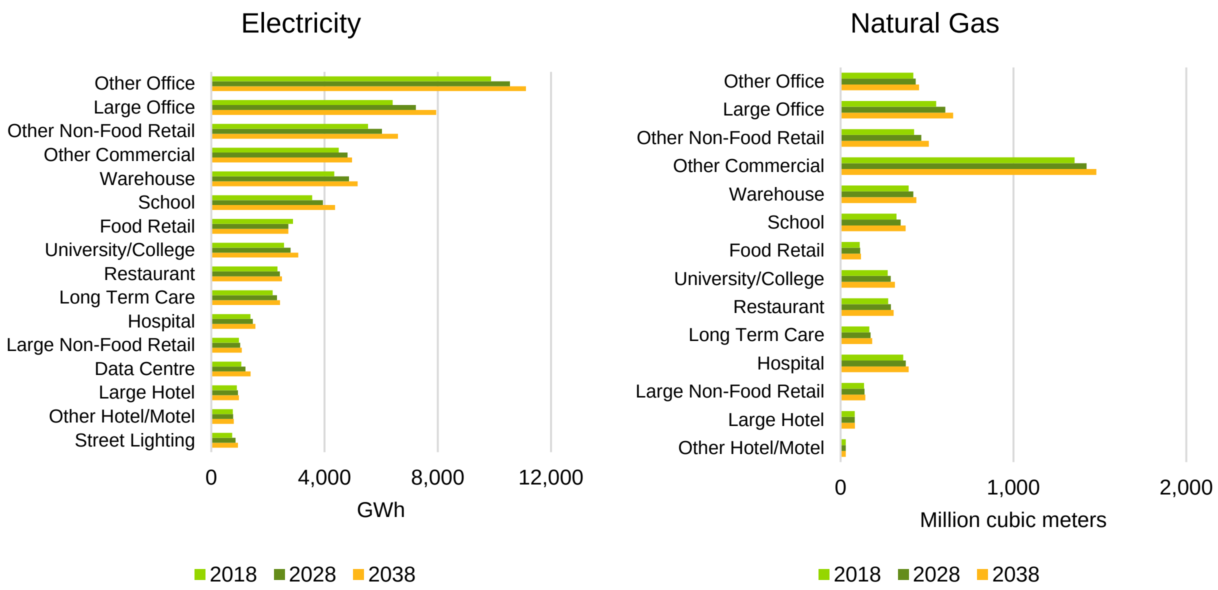
Figure 3-12. Commercial Electricity Consumption by Year, by IESO Zone



Sources: Navigant analysis, IESO

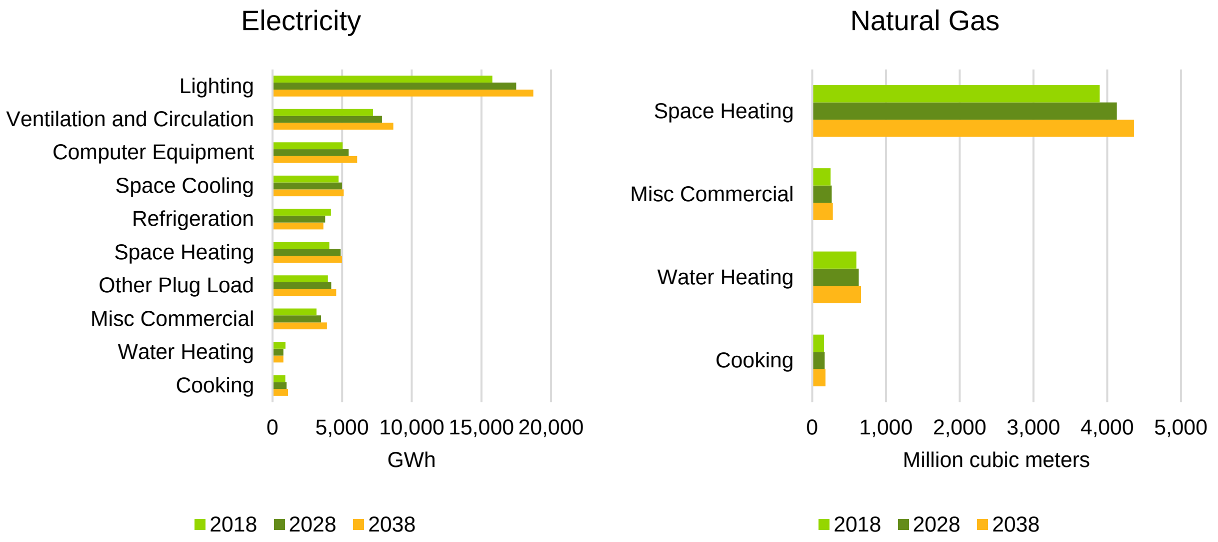
The division of electricity consumption across the 10 IESO zones does not vary significantly over the forecast period. Similar to natural gas, the East and Northeast zones slightly decrease their sectoral share of consumption, while zones with large population centres (e.g., Toronto, Southwest, Ottawa) increase their overall sectoral share.

Figure 3-13. Commercial Consumption by Segment (Natural Gas and Electricity)



Sources: Navigant analysis, IESO, Enbridge Gas, Union Gas

Figure 3-14. Commercial Consumption by End Use (Natural Gas and Electricity)



Sources: Navigant analysis, IESO, Enbridge Gas, Union Gas

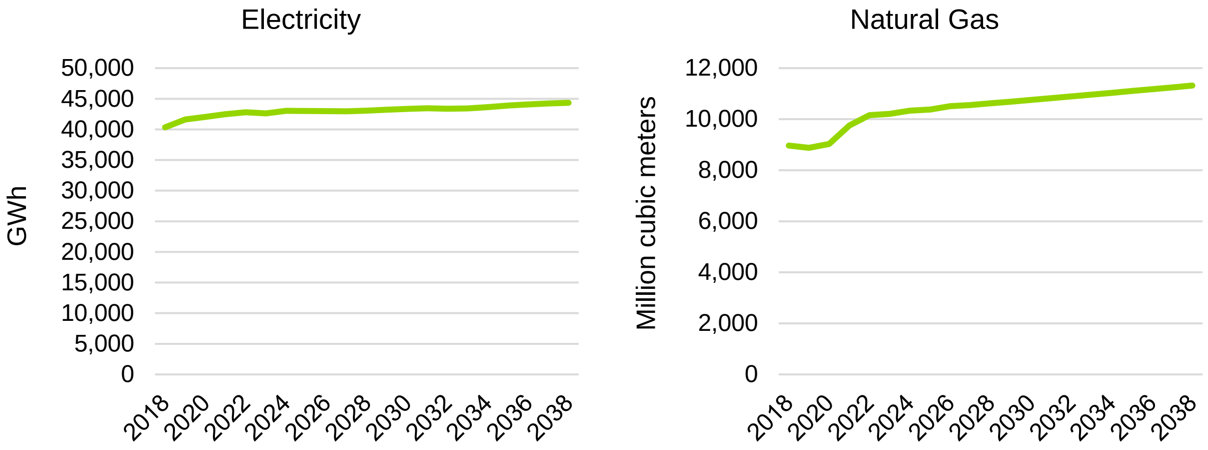
For electricity, only one segment (food retail) decreases slightly in consumption over the forecast. Refrigeration makes up a significant portion of total consumption and sees a decrease in consumption over the forecast period. All other segments experience growth over the period. Growth in these segments is driven by various end uses, a key one being lighting, which experiences growth for all segments over the forecast period.

For natural gas, all segments and end uses experience growth throughout the forecast period. The other non-food retail and large office segments see the most growth over the forecast period. Growth in both segments is driven by proportionate increases in consumption across all end uses.

3.3.4 Industrial Results

The industrial electricity trends are driven by the IESO assumptions that underlie the end use forecast provided by segment and end use, which Navigant has mapped to those defined for this potential study. A natural gas end use forecast was not available and hence the trends are driven by the total sectoral trend. This is due to the sectoral forecast being disaggregated down to the segment and end use level using the more detailed breakdown provided for the base year and holding those allocation factors constant over the reference forecast period.

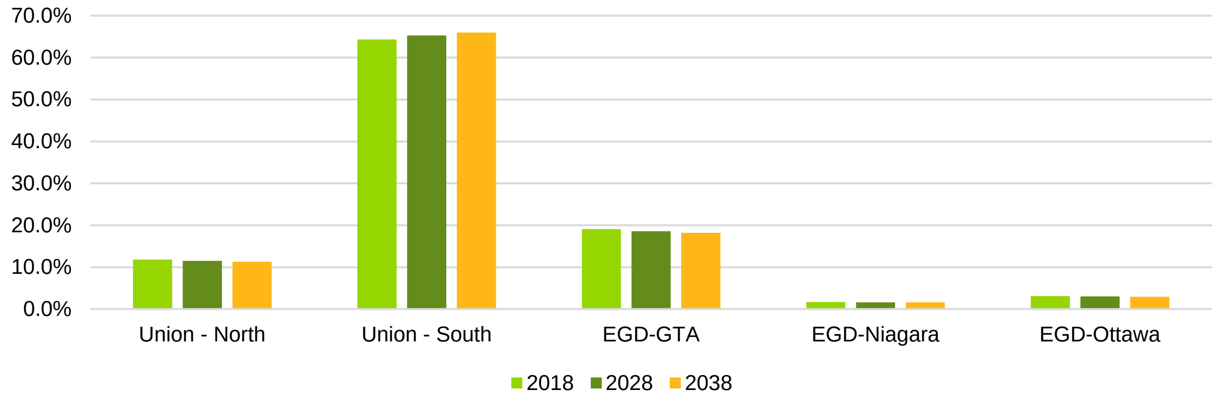
Figure 3-15. Total Industrial Consumption by Year (Natural Gas and Electricity)



Sources: Navigant analysis, IESO, Enbridge Gas, Union Gas

Figure 3-15 shows the total consumption in the industrial sector for both fuel types from 2018 to 2038. Total industrial natural gas consumption increases from 9,000 million cubic meters in 2018 to 11,300 million cubic meters in 2038, increasing an average 1.2% per year. Total industrial electricity consumption increases from 40,300 GWh in 2018 to 44,300 GWh in 2038, increasing an average 0.5% per year.

Figure 3-16. Industrial Natural Gas Consumption by Year, by Natural Gas Region

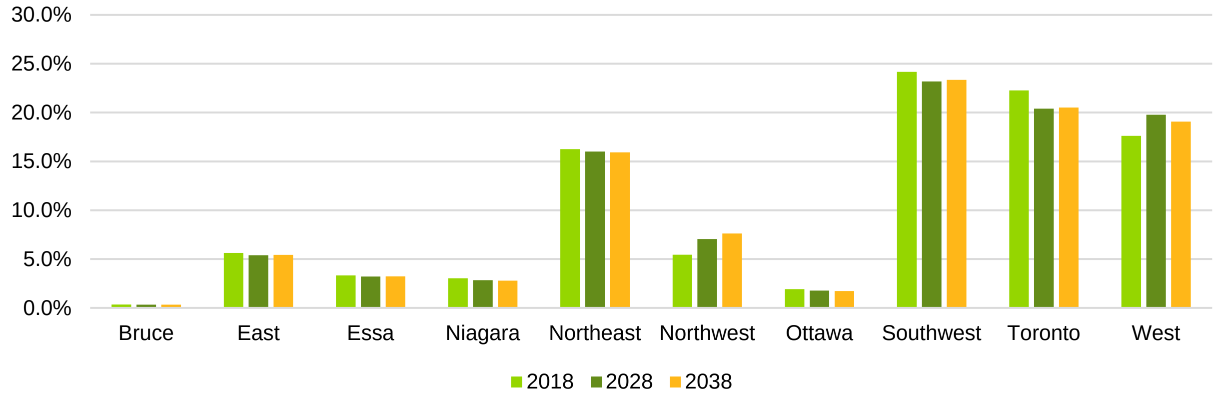


EGD = Enbridge

Sources: Navigant analysis, Enbridge Gas, Union Gas

The division of industrial natural gas consumption across the five natural gas regions does not vary significantly over the reference forecast period.

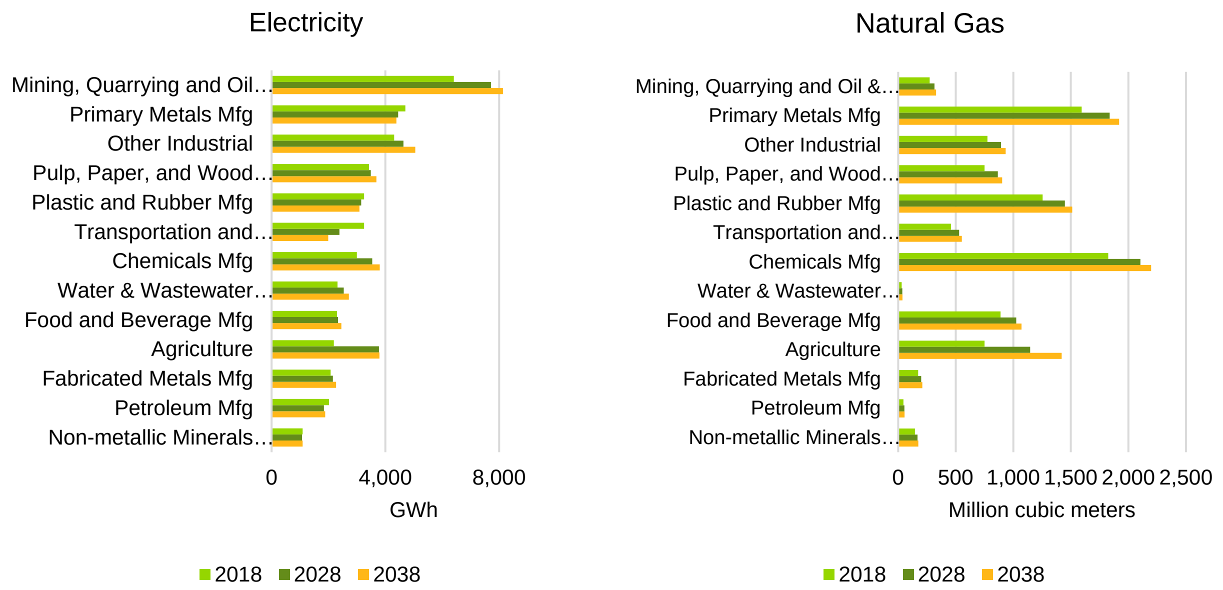
Figure 3-17. Industrial Electricity Consumption by Year, by IESO Zone



Sources: Navigant analysis, IESO

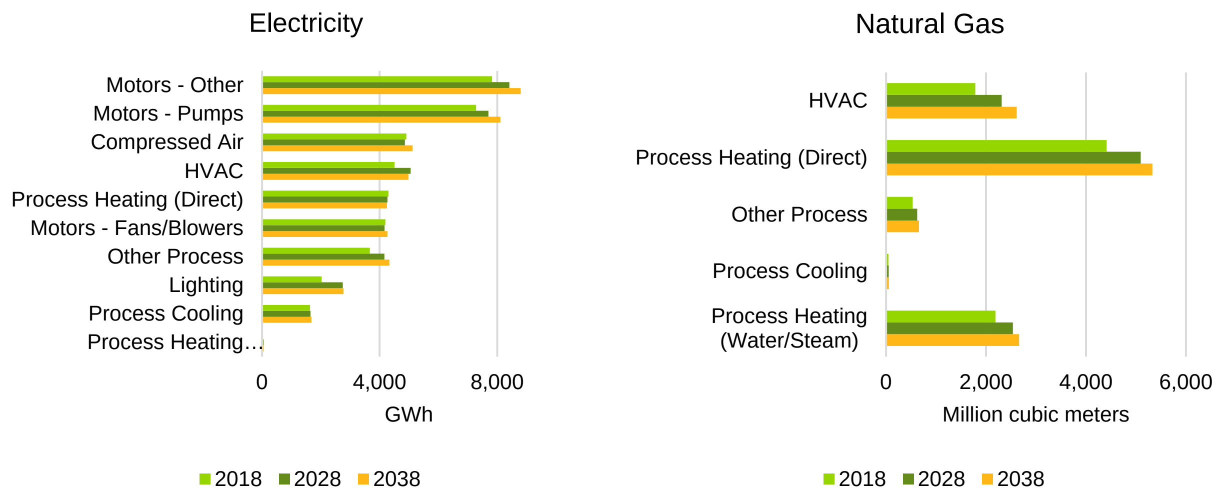
The allocation of industrial sector consumption across the 10 IESO zones throughout the forecast period changes at a larger rate than the commercial or residential sector. Most notably, the Northwest zone increases its share of consumption due to a large increase in electricity consumption in the mining segment. The West zone experiences an increase in sectoral consumption due to the increased consumption in the agriculture segment, mostly caused by forecast growth of greenhouses in the zone (more information can be found in Appendix B.3).

Figure 3-18. Industrial Consumption by Segment (Natural Gas and Electricity)



Sources: Navigant analysis, IESO, Enbridge Gas, Union Gas

Figure 3-19. Industrial Consumption by End Use (Natural Gas and Electricity)



Sources: Navigant analysis, IESO, Enbridge Gas, Union Gas

The consumption across all the natural gas segments increases over the forecast period. The agriculture segment grows the largest amount. This growth, as described further in Appendix A.2.3, is largely attributed to increased consumption from greenhouse new construction in the West IESO zone. Growth in the agriculture segment drives the forecast increase in HVAC consumption, which more than doubles over the forecast period.

For electricity, the agriculture segment also increases the largest amount due to increased greenhouse consumption in the West zone. The greenhouse consumption contributes significantly to increased consumption for lighting and HVAC end uses. Petroleum, plastic and rubbers, primary metals, and transportation and machinery manufacturing are the only segments that see a decline, which is driven by a decline across all end uses. In the transportation and machinery manufacturing segment, the motors (fans/blowers) and direct process heating end use consumption decreases significantly. Decreased consumption in the primary metals manufacturing segment is driven primarily by a large decrease in the HVAC end use.

All the natural gas end uses experience growth. Only one electric end use (process heating, direct) decreases very slightly over the forecast period, while the rest see increases.

4. MEASURE CHARACTERISATION

A measure is a type of technology, process, or project that is implemented to reduce the consumption of energy in a home or a building (e.g., LED light bulbs, building recommissioning, or air compressor optimisation). They are the building blocks of conservation potential in this potential study. Measure characterisation is the process of defining key parameters and input assumptions for the electricity and natural gas energy efficiency measures.

This chapter of the potential study report is divided into three sections:

1. **Scope:** Defines the key inputs of measure characterisation and analysis.
2. **Methodology:** Provides a high level description of the key assumptions and data sources for measure parameters.
3. **Results:** Outlines the outcomes of this task.

4.1 Scope

The purpose of the measure characterisation task was to review and compile the measure input assumptions needed to calculate technical, economic, and achievable potential (as described in subsequent chapters). This task involved several major components:

- **Measure List Development:** Navigant worked with the Project Team and Advisory Group members to develop a list of existing and new measures that can contribute to energy efficiency potential in Ontario. In total, 207 electricity, 70 natural gas, 80 dual fuel measures, and eight fuel switching measures were identified.
- **Measure Characterisation:** Navigant compiled measure input assumptions for various parameters including energy and peak demand savings, incremental costs, density, and saturation for each the main measure type, including:
    - Energy efficiency measures
    - Fuel switching measures
    - Demand response (DR) measures
- **Codes and Standards Adjustments:** Navigant adjusted the measure savings assumptions to address the effects of codes and standards, which decrease in future energy savings potential.

4.2 Methodology

The methodology section is further divided into measure list development, measure characterisation, and codes and standards adjustments sections to cover all aspects of this task.

4.2.1 Measure List Development

To identify measures, Navigant reviewed existing data sources, such as IESO's Measure Assumptions List (MAL), the OEB Technical Reference Manuals (TRMs), and the 2016 Natural Gas Conservation Potential Study, among others, and created a comprehensive list of measures for this potential study. Due to the high volume of measures initially identified, measures were consolidated where appropriate. Navigant further supplemented this list by adding other measures promoted by energy efficiency program implementers in other jurisdictions. Navigant characterised 297 pre-defined measures across Ontario's residential single-family and multifamily, commercial, and industrial sectors.

Following the review of these pre-defined measures, Navigant expanded the measure review to identify 20 additional sector-specific measures that could have a meaningful impact on potential over the planning horizon. Examples include emerging technologies and commercially available measures that may or may not be included in other jurisdictions' portfolios, such as network-connected lighting, freezer case light sensors, and natural gas heat pump water heaters.

The final measure list, including pre-defined and new measures by sector, is documented in Appendix C.

4.2.2 Measure Characterisation

The measure characterisation consisted of defining input assumptions for approximately 50 individual parameters (defined in Table 4-1) for each of the 317 measures included in this potential study.

Table 4-1. Measure Characterisation Parameters

Parameter Name	Definition	Example
Baseline	Existing inefficient equipment or process to be replaced.	Central Air Conditioner 15 SEER
Energy Efficiency Measure	Efficient equipment, process, or project to replace the baseline.	ENERGY STAR Central Air Conditioner 18 SEER
Measure Lifetime	The lifetime in years for the baseline and the energy efficiency measure.	16 years
Measure Costs	The costs of the baseline and efficiency measure including equipment, material and labour costs.	Baseline cost: $2,404 Efficient cost: $3,018
Replacement Type	Identifies when in the technology or building's life an efficiency measure is introduced. Replacement type affects when in the potential reference forecast period the savings are achieved as well as the duration of savings and is discussed in greater detail in Section 5.2.1.	Retrofit (RET), replace-on-burnout (ROB) and new construction (NEW)
Annual Energy Consumption	The annual energy consumption in electricity (kWh), demand (kW) and natural gas (m^3) for each baseline and energy efficiency measure.	Baseline: 196 kWh/year Efficient: 163 kWh/year
Unit Basis	The normalising unit for energy, demand, cost, and density estimates.	Per bulb, per hp, per kWh consumption.
Scaling Basis	The unit used to scale the energy, demand, cost and density estimate for each measure according to the reference forecast.	Per home, per 1,000 sq. ft. of commercial area, etc.
Zone	IESO zones as defined in the Base Year Disaggregation Section.	Southwest
Weather Zone	All weather-sensitive measures[27] were characterised for each of the ASHRAE weather zones in Ontario.[28]	The three ASHRAE zones that exist in Ontario are Z5, Z6, and Z7.
Sector and End Use Mapping	Each measure was mapped to the appropriate end use, customer segments, and sectors across Ontario. The Base Year and Reference Forecast sections describe the customer segments within each sector.	ENERGY STAR room air conditioners are mapped to the space cooling end use in the single-family and MURB segments.

---

[27] The high efficiency furnace 95% AFUE measure was characterised using the OEB TRM values and not the ASHRAE data due to difference in weather- and usage-related assumptions between the two sources.

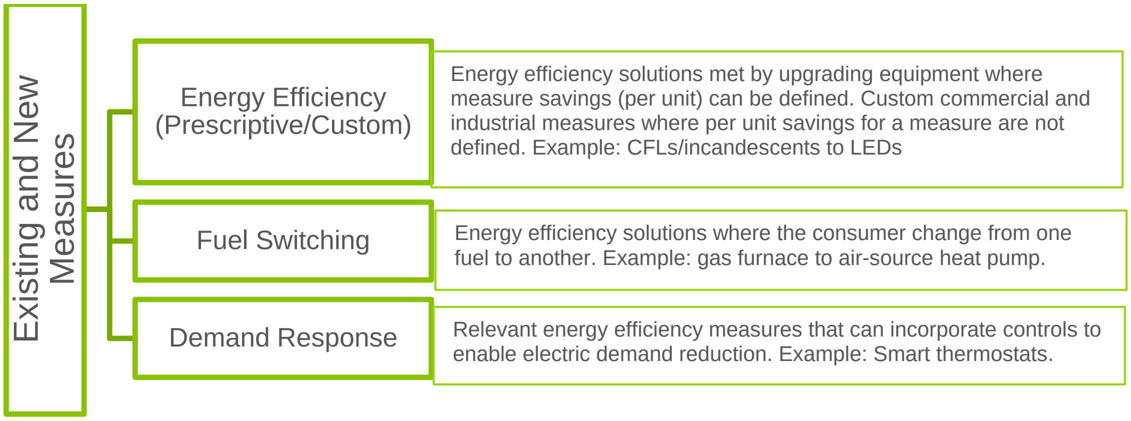
[28] http://www.oaa.on.ca/images/docs/1335971113_OAAOBCSB-102012Changesv1.2CZ6.pdf

Parameter Name	Definition	Example
Fuel Type Applicability Multipliers	Applies an adjustment to the total equipment stock to differentiate the proportion of the population that has equipment fuelled by either natural gas or electricity.	For a natural gas storage water heater this multiplier is only applicable to natural gas stock only.
Measure Density	Used to characterise the occurrence or count of a baseline or energy efficiency measure, or stock, within a residential household or within 1,000 square feet of a commercial building. This parameter was not defined for industrial measures.	35 bulbs per household
Energy Efficiency Saturation	The fraction of the residential housing stock or commercial building space that has the efficiency measure installed in a given year. For the industrial sector, saturations are based on energy consumption.	40% of all residential bulbs are LEDs so saturation of LEDs is 40%.
Technical Applicability	The percentage of the baseline technology that can reasonably and practically be replaced with the efficiency measure.	Occupancy sensors have a technical applicability of less than 1.0 because they are only practical for interior lighting fixtures that do not need to be on at all times.
Competition Group	Identifies measures competing to replace the same baseline density in order to avoid double counting of savings. Section 5.2.2 provides further explanation on competition groups.	Efficient storage tank water heater or a tankless water heater can replace an inefficient storage water heater, but not both.
Measure Stacking	Identifies measure that may be installed in the same end use in the same building. Measure stacking accounts for overlap of these measures and is discussed in detail in Section 5.2.5.	Each measure is defined as Envelope, Engine, or No Stack Engine = LED General Service Lamps Envelope = Occupancy Sensor

Source: Navigant analysis

The data source and method to calculate certain measure input assumptions varied depending on the type of measure. Figure 4-1 outlines the main measure categories used for this potential study.

Figure 4-1. Measure Categorisation



Energy efficiency solutions met by upgrading equipment where measure savings (per unit) can be defined. Custom commercial and industrial measures where per unit savings for a measure are not defined. Example: CFLs/incandescents to LEDs

Energy efficiency solutions where the consumer change from one fuel to another. Example: gas furnace to air-source heat pump.

Relevant energy efficiency measures that can incorporate controls to enable electric demand reduction. Example: Smart thermostats.

Source: Navigant analysis

4.2.2.1 Energy Efficiency Measure Characterisation

Energy Savings and Incremental Costs

Electricity and natural gas savings were characterised for each household, for every residential measure, and per 1,000 sq. ft. for each commercial measure. For prescriptive residential and commercial electric measures, Navigant used standard engineering algorithms from substantiation sheets that support IESO's MAL. For prescriptive residential and commercial natural gas measures, Navigant used standard engineering algorithms from the OEB TRM. For measures outside the MAL and the OEB TRM, Navigant used algorithms as a part of other TRMs (see Appendix C.1.5) to estimate unit energy savings.

All industrial measures were treated as custom measures. Navigant defined industrial measure savings as a percentage reduction of the customer segment and end use consumption. Navigant quantified average site-level technically feasible remaining potential for each measure based on available sources. Site-level technically feasible potential is implicitly baseline site-level savings, adjusted for technical suitability and saturation.

The primary sources for measure savings and costs were derived from the Industrial Assessment Center (IAC).[29] Navigant used the savings *opportunities* identified by IAC auditors (but not necessarily implemented/adopted) to quantify the segment-level remaining technical potential. Appendix C.1.6 provides more detail on the process followed by the IAC to determine remaining measure-level potential. These estimates were reviewed and adjusted based on feedback from industrial subject matter experts at the IESO and the natural gas utilities as well as Ontario-based evaluation, measurement, and verification (EM&V) reports. Navigant also compared the estimates for high priority measures to the 2016 Natural Gas Conservation Potential Study values and adjusted them on a case by case basis.

Peak Demand Savings

Navigant used existing IESO load profiles from the IESO cost-effectiveness tool[30] to calculate summer peak demand estimates. Navigant used the peak period definition for weather sensitive and non-weather sensitive measures as defined by IESO's EM&V Protocols and Requirements.[31] The peak period definition is from June-August between 1 p.m. and 7 p.m. (adjusted for daylight savings). An average of the load shape factors during this time was taken to develop the peak load savings factor for non-weather sensitive measures. For weather sensitive measures, this was weighted by 30% in June, 39% in July, and 31% in August, as provided in the peak period definition. The load shape factors were weighted accordingly to calculate the peak load savings factor for weather sensitive measures.

Densities and Saturation

For residential measures, density values were derived from IESO's REUS. The density values were developed by triangulating IESO's REUS data with density values for similar measures from other Canadian and US potential studies. For natural gas residential measures, Navigant also leveraged end use surveys conducted by Union and Enbridge to derive density estimates. For commercial measures, density was primarily derived from other potential studies as there was limited Ontario-specific data available for this sector.

---

[29] Office of Energy & Renewable Energy, Industrial Assessment Centers (IACS), https://www.energy.gov/eere/amo/industrial-assessment-centers-iacs

[30] Independent Electricity System Operator, IESO CDM Cost-Effectiveness Tool, http://www.ieso.ca/-/media/Files/IESO/Document-Library/conservation/EMV/2019/IESO-CDM-CE-Tool-V7-20191002.xlsb?la=en

[31] Independent Electricity System Operator, EM&V Protocols and Requirements, http://www.ieso.ca/-/media/Files/IESO/Document-Library/conservation/EMV/2019/IESO-EMV-Protocols-and-Requirements-V3-1Apr2019-vf.pdf?la=en

Saturation values for residential measures were informed from IESO's REUS and supported by other potential studies. For commercial measures, these were primarily derived from other potential studies. The density and saturation values of measures were then adjusted based on the EUI of the segments within a zone.

4.2.2.2 Fuel Switching

Navigant included fuel switching measures (i.e., measures that replace natural gas or electricity consumption with another fuel source) in the potential study. These measures had similar sources for savings and costs as the relevant energy efficiency natural gas or electric measures. Densities and saturation values for these measures were taken from Ontario-specific sources, if available. Navigant took the densities and saturation values for these measures from other Canadian potential studies when Ontario-specific data was not available.

The potential for fuel switching was modelled separately from the potential for energy efficiency. This is because while fuel switching measures compete among themselves for potential, they do not often compete with energy efficiency measures applied to the same end use because they tend to be less cost-effective. For example, a customer is more likely to replace a natural gas furnace with a more efficient natural gas furnace than with an electric heat pump since the cost to convert the heating system to electricity is high.

The fuel switching analysis was limited to measures that can replace natural gas use with electricity. Given the wide usage of natural gas in Ontario and the low carbon intensity of Ontario's grid, switching to electricity provides greenhouse gas (GHG) emissions reductions over its lifetime.

Navigant included measures that replace natural gas space or water heating measures in the commercial or residential sectors to calculate the fuel switching potential. Navigant focused on space heating and water heating end uses, as natural gas consumption within these end uses composes upwards of 70% of the total natural gas consumption within the residential and commercial sectors.

4.2.2.3 DR Measure Characterisation

Navigant quantified the associated DR potential for energy efficiency measures that can incorporate sufficient controls to enable electricity demand reduction including:

Residential DR-enabling technologies

- Adaptive Thermostats
- Variable Speed Pool Pump Motors

Commercial DR-enabling technologies

- Adaptive Thermostats
- Advanced BAS Controllers
- Central Lighting Control Systems
- Networked/Connected Lighting – High Impact Application
- Networked/Connected Lighting – Low Impact Application

Peak Period for DR

IESO provided Navigant with the peak period definition to be used for the DR analysis consistent with the summer period for DR resources in the IESO's DR Auction. This is the period within which DR resources wishing to participate in the DR auction were required to be available. In the summer period (from May 1 to October 31), DR resources had to be available on business days from 12:00 to 21:00 EST (hour ending 13 to hour ending 21).[32] DR potential was estimated only for the summer period.

4.2.3 Codes and Standards Adjustments

As codes and standards take effect, the energy savings from efficiency measures impacted by the relevant codes or standards decline as the baseline becomes more efficient. This change affects the overall potential of the measure beyond the year the code or standard goes into effect. Navigant accounted for the effect of codes and standards through baseline energy and cost multipliers (sourced from Natural Resources Canada's [NRCan's] and the Department of Energy's [DOE's] analysis), which reduce the baseline equipment consumption starting from the year a code or standard takes effect.

For example, Navigant incorporated the 2020 incandescent and halogen lighting provision[33] in this potential study, which results in the baseline for general service lighting changing from an average wattage of incandescent, halogen, and CFLs to a CFL-level wattage only in 2020. Accordingly, the model accounted for reduced energy consumption and increased baseline cost in 2020 through the codes and standards multipliers. As such, computed measure-level potential was net of implemented codes and standards. The model also accounted for the decreased cost for LED lighting over the potential reference forecast period. The cost multipliers for LEDs were developed from DOE's Solid-State Lighting Forecast Report.[34]

NRCan's Amendment 15[35] (Part 2) was published on June 12, 2019, putting in place more stringent standards for natural gas furnaces and fireplaces. Given the timing of this potential study, Navigant did not incorporate any relevant codes and standards assumptions in the current potential study.

4.3 Results

This task resulted in all measure-level model inputs. See Appendix C.1 for the measure list used for this potential study.

---

[32] Email correspondence with the Project Team (IESO) 2019-02-05

[33] Energy Independence and Security Act, 2007, https://www.govinfo.gov/content/pkg/PLAW-110publ140/pdf/PLAW-110publ140.pdf

[34] Department of Energy, Solid State Lighting Forecast Report, https://www.energy.gov/eere/ssl/ssl-forecast-report

[35] Natural Resources Canada, *Amendment 15 (Part 2) to the Energy Efficiency Regulations*, https://www.nrcan.gc.ca/energy-efficiency/energy-efficiency-regulations/forward-regulatory-plan-2019-2021/amendment-15-energy-efficiency-regulations/19384

5. TECHNICAL POTENTIAL

This section describes Navigant's approach to calculating technical potential and presents the results for Ontario.

The objective of the technical potential task is to provide an estimate of the technically feasible energy conservation potential across the 20-year reference forecast period covered by the potential study. The technical potential provides an upper bound to the projected achievement of future conservation efforts and is unconstrained by considerations of cost-effectiveness (captured by the economic potential) or questions of consumer adoption (captured by the various achievable potential scenarios). The technical potential is driven by inputs provided by the reference forecast and measure characterisation tasks.

This chapter of the report is divided into three sections:

1. **Scope:** Defines the key outputs generated as part of the technical potential analysis.
2. **Methodology:** Provides a high level description of the key assumptions and analytic approaches used to estimate the technical potential. Additional detail on select methods are found in Appendix D.
3. **Results:** Provides a summary of the results of the technical potential estimation.

5.1 Scope

The goal of the technical potential analysis is to estimate the combined maximum technical potential (given interactions, competition) of the energy conservation and fuel switching measures characterised as part of the measure characterisation task. The estimation of technical potential addresses the following considerations (see Section 5.2 for more details):

- **Measure replacement types:** Measures may be installed at the time of building construction (new), after construction but before the end of the measure's useful life (retrofit) or at the end of a measure's useful life (replace-on-burnout).
- **Competing measures:** Cases in which two or more mutually exclusive measures exist (e.g., storage water heaters and tankless water heaters).
- **Persistence and market transformation:** The assumption that programmatically driven measure adoption moves the market forward, resulting in consumers replacing their efficient measures on a like-for-like basis at the end of their expected useful life.
- **Interactive effects:** Some measures impact both electricity and natural gas potential in opposite directions. For example, a heat recovery ventilator reduces natural gas space heating consumption but increases electric ventilation consumption.
- **Measure stacking:** When two measures that share the same end use are installed at the same time, the total savings of the two combined may be less than the sum of their individual savings. For example, adding insulation to a home and replacing the furnace will deliver an aggregate savings that is less than the savings of these two measures on their own.

The key outputs of this analysis are:

- **Electric energy technical potential (GWh)** from energy conservation measures.
- **Natural gas technical potential (millions of m^3)** from energy conservation measures.

- **Electric peak demand technical potential (MW)** from energy conservation measures.[36]
- **GHG emissions reductions (Mt CO2e)** associated with the technical potential values cited above.
- **Fuel switching technical potential.** Natural gas technical potential and electric energy incremental consumption from fuel switching measures.[37]
- **The electric DR potential (MW)** associated with technically feasible adoption of electric energy conservation measures considered in this study. Only those energy conservation measures that may be remotely controlled by a program administrator after only minor modifications are made are considered for this output.[38]

5.2 Methodology

For the residential and commercial sectors, technical potential is calculated on a per-measure basis. This is calculated based on estimates of savings per unit, measure density (e.g., quantity of possible measures per home), measure saturation (the proportion of the density already occupied by efficient measures) and total building stock in each service territory. These inputs that are defined in the base year, reference forecast, and measure characterisation tasks. Industrial potential is calculated in the same manner, except that rather than scaling measure savings on a per-unit basis, measure savings are scaled in proportion to the relevant reference forecast consumption.[39]

5.2.1 Measure Replacement Type

Navigant considers three types of measure replacement in this study:

Replacement Type: NEW

The cost to implement new construction (NEW) measures is incremental to the cost of a baseline (and less efficient) measure. However, NEW technical potential is driven by equipment installations in new building stock rather than by new equipment in existing building stock.[40] New building stock is added to keep up with forecast growth in total building stock and to replace existing stock that is demolished each year. Demolished (sometimes called replacement) stock is calculated as a percentage of existing stock in each year. New building stock (the sum of growth in building stock and replacement of demolished stock) determines the annual incremental addition to technical potential (AITP), which is then added to totals from previous years to calculate the total potential in any given year. Navigant used Equation 5-1 to calculate technical potential for NEW measures.

Equation 5-1. New Measures Technical Potential

$$AITP = New\ Stock\ x\ Measure\ Density\ x\ Savings\ x\ Technical\ Suitability$$

---

[36] Summer peak demand potential in this study is defined as the average demand during the period from 1pm through 7pm on non-holiday weekdays in June, July, and August, as per the IESO EM&V Protocols. See Table 1 and 2 of:

Independent Electricity System Operator, *Evaluation, Measurement and Verification Protocols and Requirements V3.0*, April 2019

[37] This potential study considers only natural gas-to-electric fuel switching measures. The approach and findings related to this output may be found in Appendix D.

[38] The approach and findings related to this output may be found in Appendix D.

[39] This difference in approach is due to the heterogeneity of building sizes within a given segment in the industrial sector, and the fact that forecasts of industrial building stock are not typically available, as they are for the residential and commercial sectors.

[40] In some cases, customer-segment-level and end use-level consumption are used as proxies for building stock. These consumption figures are treated like building stock in that these are subject to demolition rates and stock-tracking dynamics.

Where:

- *Annual Incremental NEW Technical Potential (AITP):* kWh or m^3
- *New Stock*:[41] Commercial floor space per year, residential households per year, or customer segment consumption per year
- *Measure Density*: Measure unit per unit of stock[42]
- *Savings*: kWh or m^3 per measure unit per year
- *Technical Suitability*: Ratio between 0 and 1 to represent the percentage of situations the measure is technically suitable for the application

Replacement Type: RET and ROB

Retrofit (RET) measures are either early replacement measures (e.g., early water heater replacement) or measures for which the baseline is simply the absence of a measure (e.g., additional insulation, lighting controls, etc.). RET measures can also be efficient processes not currently in place and not required for operational purposes. When a RET measure is of the early replacement type, savings are calculated in a manner sometimes described as a dual baseline: there is an initial period (based on the remaining useful life of the technology being replaced) during which the measure baseline is the replaced technology, and then there is a later period in which the baseline is code-compliant technology. Remaining life for all early replacement RET measures is assumed to be one-third of the existing technology's expected useful life.

In contrast, replace-on-burnout (ROB) measures, sometimes referred to as lost opportunity measures, are replacements of existing equipment that has failed and must be replaced or are existing processes that must be renewed. In this study, technical potential for ROB measures is limited to the rate at which existing baseline technologies burn out or reach their end of life.

RET and ROB measures have a different meaning for technical potential compared with NEW measures. In any given year, for the residential and commercial sectors, the model uses the existing building stock to calculate technical potential. For the industrial sector, as no forecast of building stock is available, savings are scaled on the basis of reference forecast consumption. This method does not limit the calculated technical potential to a pre-assumed rate of adoption of RET measures. Existing building stock is reduced each year by the quantity of demolished building stock in that year and does not include new building stock that is added throughout the simulation. For RET and ROB measures, annual potential is equal to total potential, thus offering an instantaneous view of technical potential. The potential study team used Equation 5-2 to calculate technical potential for RET and ROB measures.

Equation 5-2. Retrofit and Replace-on-Burnout Measures, Technical Potential

$$Total\ Potential = Existing\ Stock\ x\ Measure\ Density\ x\ Savings\ x\ Technical\ Suitability$$

---

[41] Units for new building stock and measure densities may vary by measure and customer segment (e.g., 1,000 m^2 of building space, number of residential households, customer-segment consumption, etc.).

[42] Note that the manner in which density is calculated differs by sector. Please refer to the Measure Characterisation chapter for a detailed description.

Where:

- *Total Potential:* kWh or m^3
- *Existing Stock:*[43] Commercial floor space per year, residential households per year, or customer segment consumption per year
- *Measure Density:* Measure installations per unit of stock, where measure installations are defined as units of measure, such as a refrigerator or square meters of insulation
- *Savings:* kWh or m^3 per measure, per year
- *Technical Suitability:* Ratio between 0 and 1 to represent the percentage of situations the measure is technically suitable for the application

5.2.2 Competing Measures

Navigant's modelling approach recognises that some efficient technologies will compete against each other in the calculation of potential. The potential study defines competition as an efficient measure competing for the same installation as another efficient measure. For instance, a consumer has the choice to install a condensing or a near-condensing water heater, but not both, since the consumer will only install one new water heater.

General characteristics of competing technologies used to define competition groups in this study include:

- Competing efficient technologies share the same baseline technology characteristics, including baseline technology densities, costs, and consumption.
- The total (baseline plus efficient) measure densities of competing efficient technologies are the same.
- Installation of competing technologies is mutually exclusive (i.e., installing one precludes installation of the others for that application).
- Competing technologies share the same replacement type (RET, ROB, or NEW).

To address the overlapping nature of measures within a competition group, Navigant's analysis only selects one measure per competition group to include in the *summation* of technical potential across measures (e.g., at the end use, consumer segment, sector, service territory, or total level). For the technical potential estimation, the measure selected as the winner of the competition group is the measure that delivers the largest volume of savings in the given year. This ensures that sectoral technical potential acts as the upper bound for estimated potential (when compared against the economic or achievable potentials). This approach ensures that the aggregated technical potential does not double-count savings. However, the model still calculates the technical potential for each individual measure outside of the summations. The measure-level technical potential (pre-competition groups and pre-measure stacking) may be found in Appendix D.

5.2.3 Persistence and Market Transformation

The potential model also addresses the issue of persisting measure savings over the 20-year analysis period. Navigant assumes that programmatically delivered measure adoption (i.e., the measure adoption

---

[43] Units for building stock and measure densities may vary by measure and customer segment (e.g., 1,000 m^2 of building space, number of residential households, customer-segment consumption/sales, etc.).

output by the model) is market transforming—that once an installed measure reaches the end of its life, the adopter will replace it with the same efficient technology. For example, a consumer that replaces an incandescent bulb with an LED is assumed to replace that LED with another at the end of the first LED's life. Note that because the assumption is one of market transformation – the establishment of a new baseline for the given individual, no program cost is tracked for re-participation

This is sometimes also known as the re-participation rate. This study assumes a re-participation rate of 100%, meaning that all installed measures are assumed to be replaced with the same/similar efficient technology in the future once the originally installed measure reaches its end of life. Potential associated with re-participation continues to be counted in the estimated output technical potential.

5.2.4 Interactive Effects

This study defines interactive effect as a measure's savings of one fuel type impacting savings of another fuel type. For example, the installation of heat recovery ventilation delivers substantial natural gas savings via a reduction in the thermal load, but also results in increased electricity consumption associated with the required ventilation load. For this example, the model accounts for such interactive effects based on the estimated increase in ventilation load derived as part of the measure characterisation exercise.[44]

Measure interactive effects are different than measure stacking. Measure interactive effects are interactions between two measures with different end uses (e.g., LED lighting reduces cooling loads and thus savings for efficient A/C units), where measure stacking refers to interactive effects between measures that share the same end use (e.g., insulation installed at the same time as a more efficient furnace will result in combined savings that are less than the sum of the savings from the individual measures).

5.2.5 Measure Stacking

When two or more measures that impact the same end use energy consumption are installed in the same building, the total savings that can be achieved may be less than the sum of the savings from those measures independently. For example, consider a high efficiency boiler and ceiling insulation. If both are installed together in the same building, the total savings would be less than the sum of the individual measure savings: the installation of the more efficient boiler reduces the amount of natural gas required to satisfy a given thermal load, but the installation of the ceiling insulation reduces the thermal load itself.

To generalise this concept Navigant refers to measures that convert electricity or natural gas to useful outputs such as heat or light as *engine measures* (boilers, light bulbs, motors, etc.). Measures that impact the amount of energy that engines must convert are referred to as *envelope measures* (insulation, thermostats, lighting controls, etc.). Anytime an engine and envelope measure are implemented in the same building, the expectation is that savings from both measures will decrease.

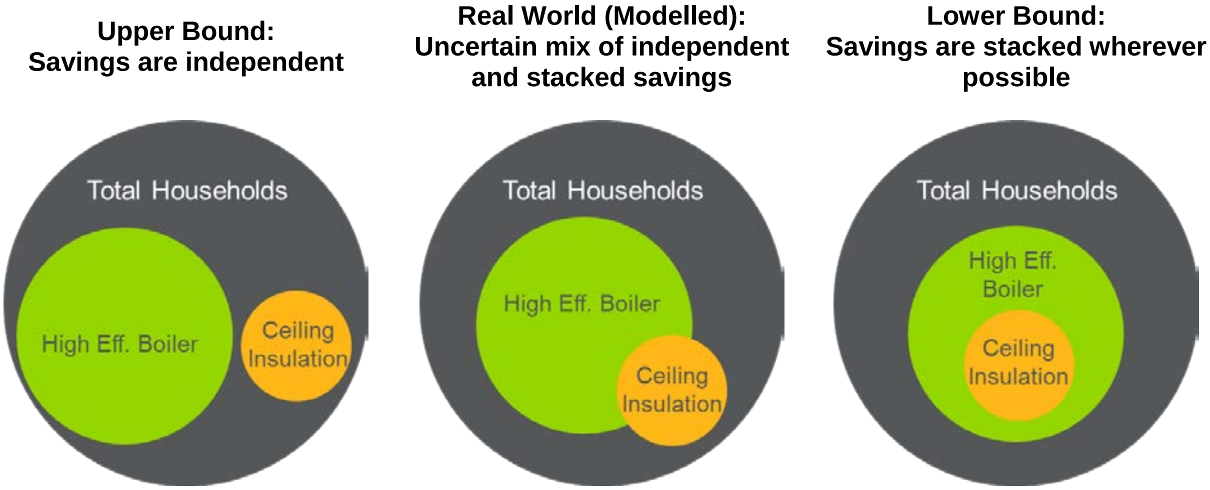
Figure 5-1 provides an illustration of three different efficiency stacking approaches. The upper bound approach assumes no overlap in measure implementation and no efficiency stacking, which leads to an upper bound on savings potential. The opposite of the upper bound approach is to assume all measures

---

[44] At the request of the OEB, Navigant has excluded the interactive effects impacting natural gas consumption associated with refrigeration and lighting measures, as being effects that would be captured in the uncertainty band of the natural gas utilities' reference case forecast. The aggregate impact of these interactive effects is very small – less than 1% of the estimated technical potential in absolute value.

are stacked wherever possible, which provides a lower bound on savings. Lastly, there is the real-world approach (modelled) where some measures are implemented in isolation and others are stacked.

Figure 5-1. Venn Diagrams for Various Efficiency Stacking Situations



Area of colored circle represents the number of households with a given savings opportunity. Overlapping circles indicate a household has implemented both measures.

Source: Navigant analysis

While the data regarding estimates of stacking in the market is quite limited, assumptions and estimations were made to address stacking to the degree possible. Specifically, to calculate the potential resulting from considering measure stacking (Stacked Potential), the unadjusted potential (Unstacked Potential) is reduced by a combination of how often stacking measures are installed in the same building (Stacking Frequency), and the reduced savings achieved when installing measures that stack (Savings Adjustment) as seen in Equation 5-3.

Equation 5-3. Potential after Stacking Calculation

$$Stacked\ Potential = Unstacked\ Potential\ x\ (1 - \ Savings\ Adjustment\ x\ Stacking\ Frequency)$$

The details regarding the assumptions and inputs used to develop the values above may be found in Appendix D.

The measure stacking adjustment is applied when measure savings are aggregated; as such, all measure-level potential is unstacked and, if summed up, will deliver a value higher than the aggregated savings at the end use.

5.3 Results

This sub-section provides DSMSim™ results pertaining to total technical potential at different levels of aggregation but always reported at the meter. The technical potential of energy efficiency measures is shown by sector, end use category, and for the highest impact measures. The associated sectoral potential emissions reductions are also provided.

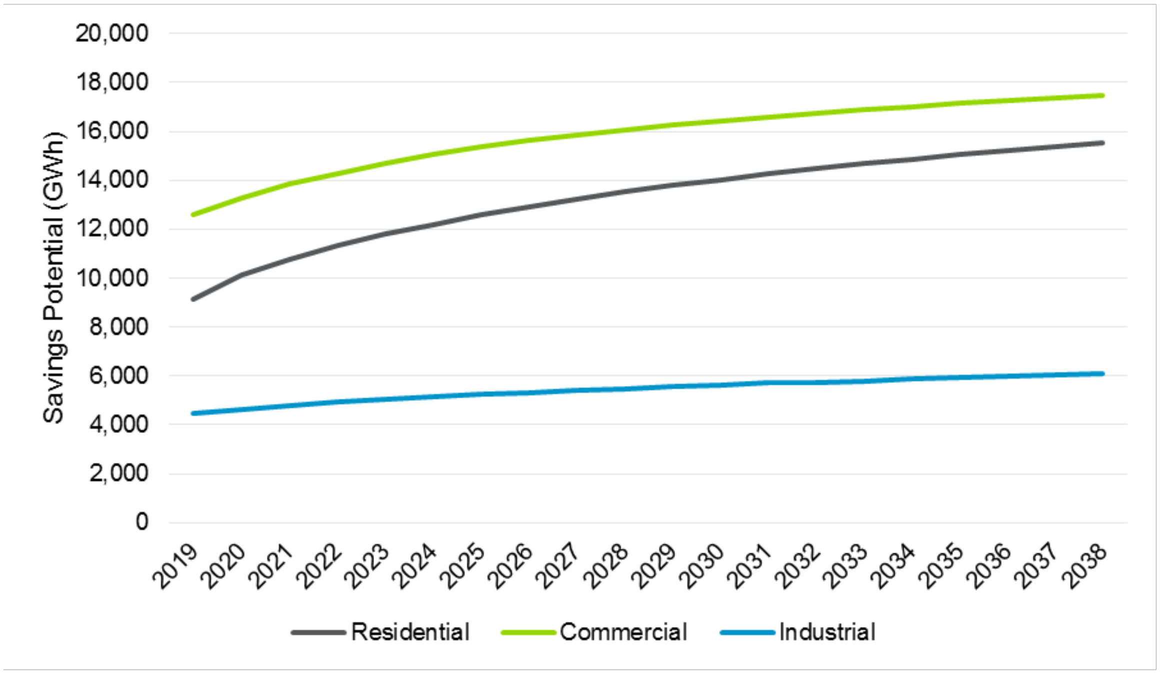
Additional outputs, including energy efficiency potential by segment, fuel switching technical potential, and the technically feasible DR potential associated with energy efficiency measures are shown in

Appendix D. This appendix also provides the energy efficiency technical potential results benchmarked against the values estimated in the 2016 Natural Gas Conservation Potential Study and by other publicly available potential studies.

5.3.1 Results by Sector

Figure 5-2 shows the total electric energy technical potential for each sector. The intercept of each curve represents the technical potential associated with RET measures—measures that could conceivably be implemented immediately. The growth over time of each curve captures the effects of NEW and ROB measures, adopted as new building stock is added, or as existing technologies reach the end of their life (respectively).

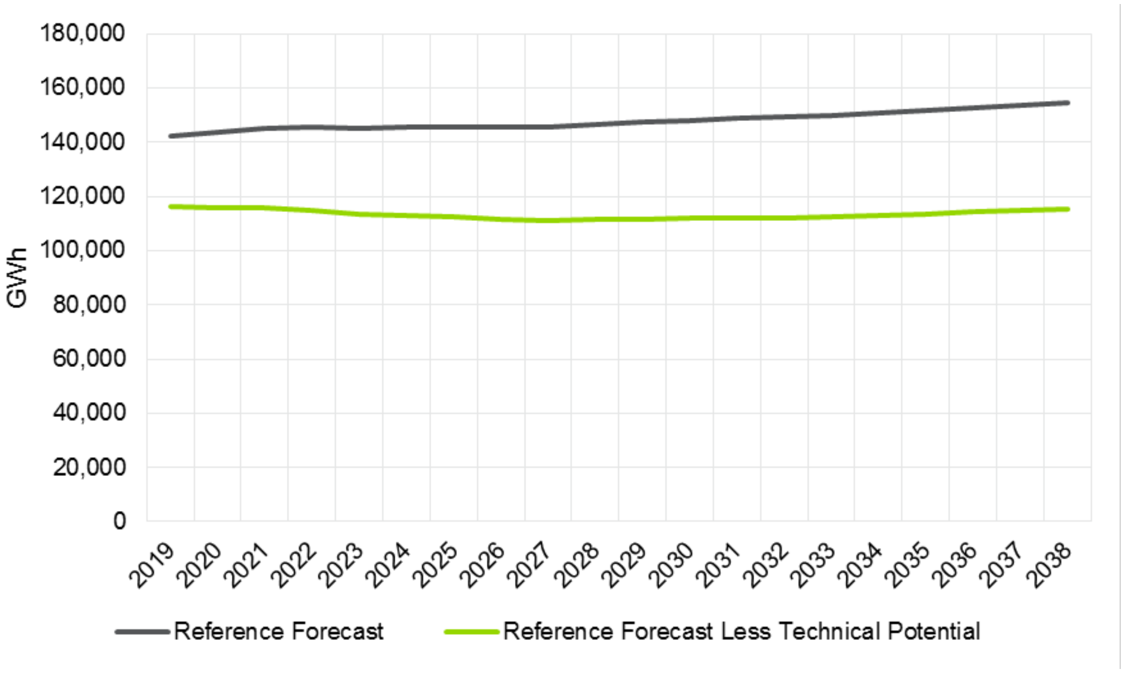
Figure 5-2. Electric Energy Technical Potential by Sector (GWh)



Source: Navigant analysis

Figure 5-3 contrasts the estimated electric technical potential across the potential reference forecast period with the total forecast consumption over the same period.

Figure 5-3. Electric Energy Reference Forecast and Technical Potential



Source: Navigant analysis

Table 5-1 provides the estimated technical potential as a percentage of total forecast consumption for three years of the reference forecast period, both by sector, and for the province as a whole.

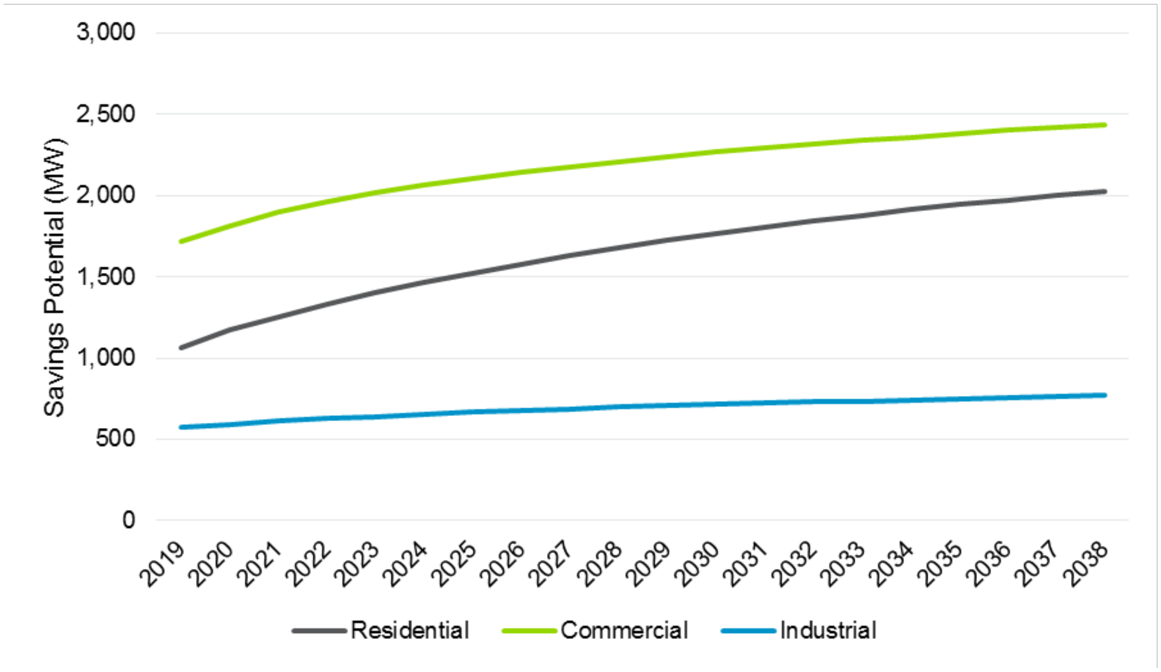
Table 5-1. Electric Energy Technical Potential as a Percentage of Forecast Consumption

Year	Residential	Commercial	Industrial	Total
2023	24%	28%	12%	**22%**
2030	28%	30%	13%	**24%**
2038	30%	30%	14%	**25%**

Source: Navigant analysis

Figure 5-4 shows the total electric summer peak demand technical potential for each sector. The intercept of each curve represents the technical potential associated with RET measures—measures that could conceivably be implemented immediately. The growth over time of each curve captures the effects of NEW and ROB measures, adopted as new building stock is added, or as existing technologies reach the end of their life (respectively). As noted earlier in this report, peak demand potential is derived through the application of the summer peak demand period definition in the IESO's EM&V Protocols to the 8,760 load profiles used in the IESO Cost-Effectiveness tool.

Figure 5-4. Electric Summer Demand Technical Potential by Sector (MW)

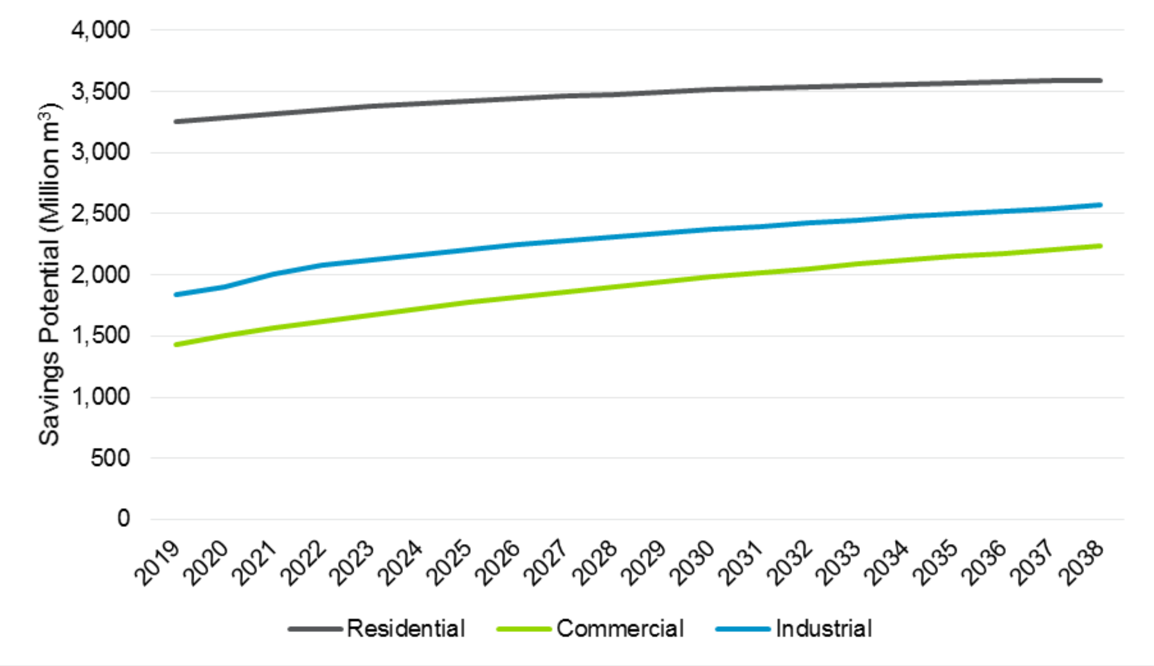


Source: Navigant analysis

The summer peak demand potential cannot be contrasted with the reference forecast in the same manner as the electric energy potential, as no long-term forecast of peak demand at the required granularity was available at the time this study was conducted.

Figure 5-5 shows the total natural gas energy technical potential for each sector. As above, the intercept on the vertical axis captures the technical potential associated with RET measures, while the growth in later years reflects the potential associated with NEW and ROB measures.

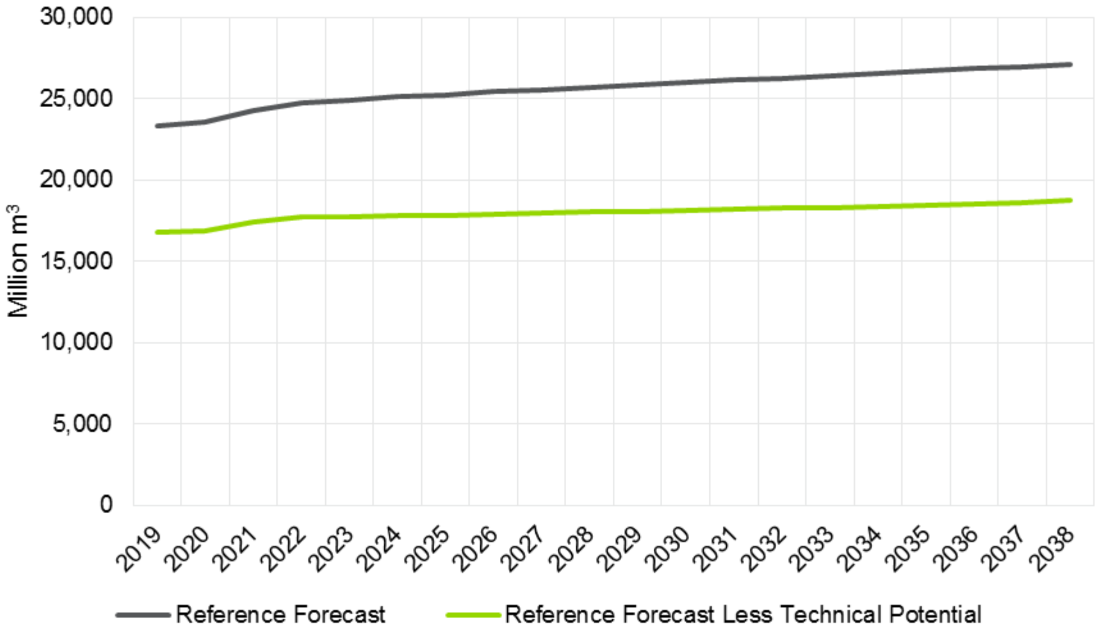
Figure 5-5. Natural Gas Energy Technical Potential by Sector (Million m^3)



Source: Navigant analysis

Figure 5-6 contrasts the estimated natural gas technical potential across the reference forecast period with the total forecast consumption over the same period.

Figure 5-6. Natural Gas Reference Forecast and Technical Potential



Source: Navigant analysis

Table 5-2 provides the estimated technical potential as a percentage of total forecast consumption for three years of the reference forecast period, both by sector, and for the province as a whole.

Table 5-2. Natural Gas Energy Technical Potential as a Percentage of Forecast Consumption

Year	Residential	Commercial	Industrial	Total
2023	35%	33%	21%	**29%**
2030	35%	38%	22%	**30%**
2038	35%	41%	23%	**31%**

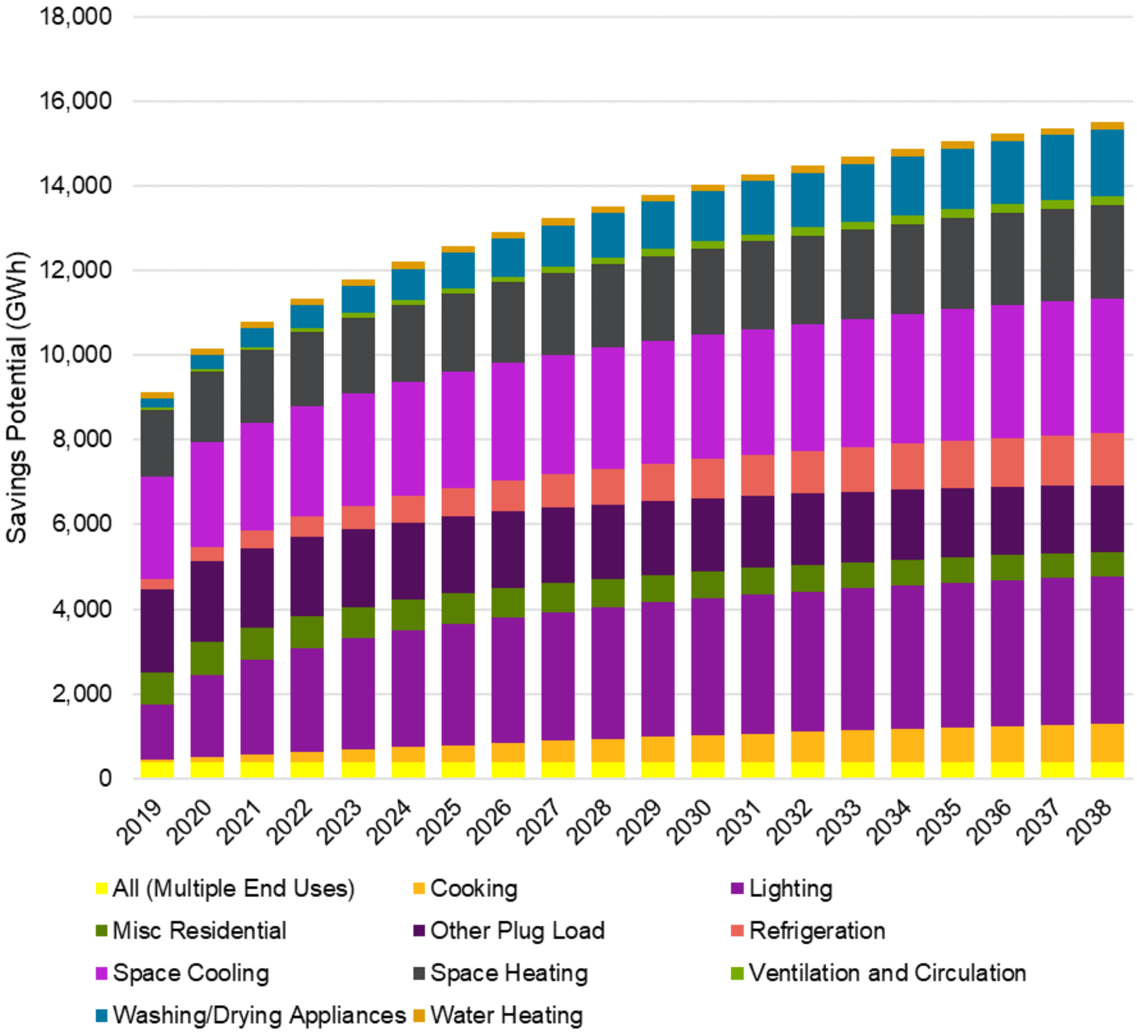
Source: Navigant analysis

5.3.2 Results by End Use and Sector

This sub-section of the results section presents end use potential by sector. These values are presented by sector, rather than across all sectors. For each sector and fuel, the time-series of energy savings potential is presented in energy units. Likewise, for each sector and fuel, end use potential as a percentage of that end use's forecast consumption is presented for three indicative years.

Figure 5-7 shows the electric energy technical potential across all residential end uses. The All (Multiple End Uses) end use captures savings from measures that deliver savings across a wide variety of end uses, measures such as home energy reports and building recommissioning (multifamily, or multi-res, residential buildings only).

Figure 5-7. Residential Electric Energy Technical Potential by End Use (GWh)



Source: Navigant analysis

The end uses in which the most technical potential exists include the lighting, space cooling, space heating, and other plug loads.

The significant amount of plug load potential is driven principally by a single measure: the tier 2 smart strip. This technology, assumed to be installed in a mix of home entertainment centres and home offices, substantially reduces electricity consumption by monitoring circuit loading and cutting power to circuits that are deemed to be providing only phantom power to electronics that are powered down.[45]

---

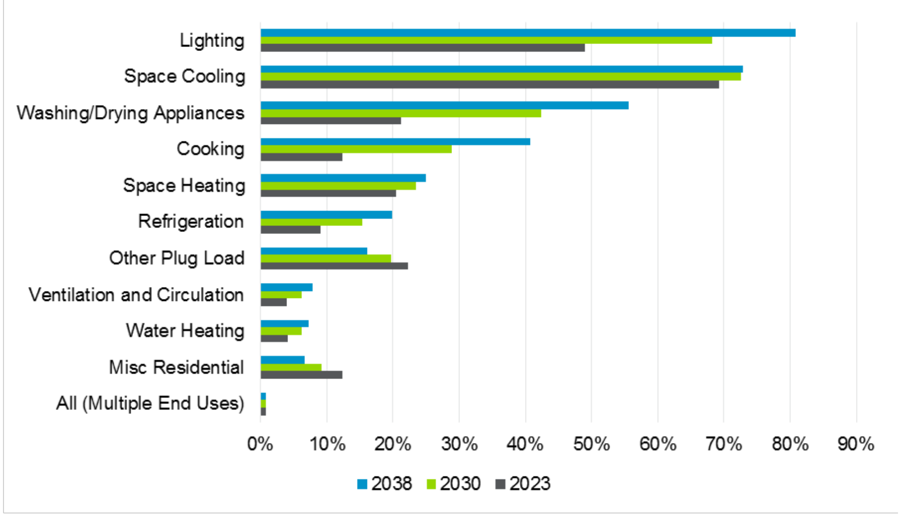
[45] Savings for this measure are derived from a meta-analysis of multiple studies of tier 2 smart strips conducted by NEEP in 2015 NEEP (2015). Case Study: Tier 2 Advanced Power Strips and Efficiency Programs. https://neep.org/sites/default/files/APSTier2CaseStudy.pdf

As may be seen in the figure above, a very high proportion of available space heating potential is driven in the early years by the deployment of RET measures (air sealing, basement insulation, etc.). In 2023, 95% of space heating potential is derived from RET measures. The turnover of building and equipment stock, however, results in an increasing share (20%) of the potential being delivered by ROB and NEW measures (heat pumps) by 2038.

Significantly, water heating potential is very low in all years. This is due to the very high level of natural conservation anticipated by the IESO reference forecast[46]—between 2019 and 2038, the reference forecast anticipates a 55% reduction in water heating electricity intensity.

Figure 5-8 shows residential electric energy savings potential by end use as a percentage of that end use's consumption for three years of the forecast, 2023, 2030, and 2038.

Figure 5-8. Residential Electric Energy Technical Potential by End Use as a Percentage of End Use Forecast Consumption



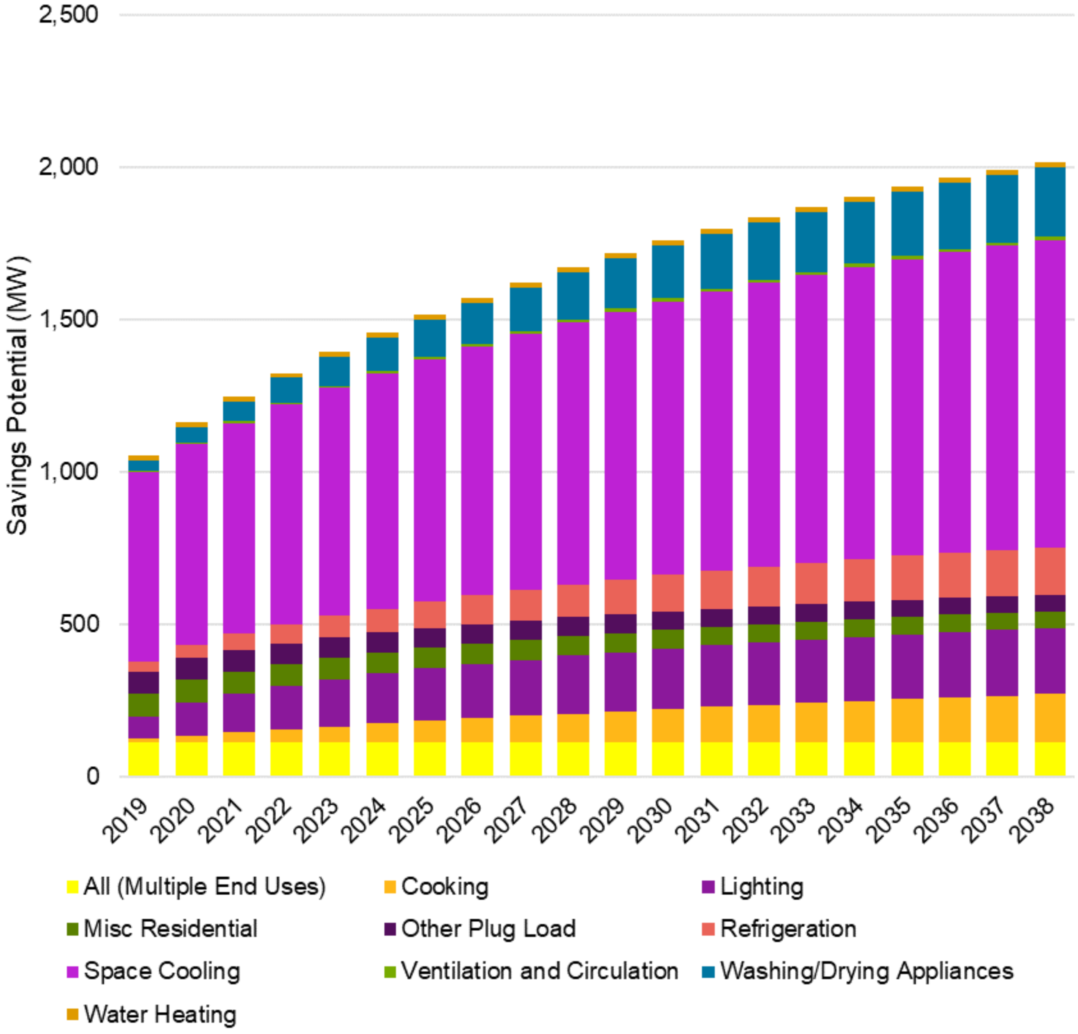
Source: Navigant analysis

---

[46] Recall that all potential estimated by this potential study is intended to be potential over and above the effects of natural conservation embedded in the reference forecast – i.e., net of free riders.

Figure 5-9 shows the electric demand technical potential across all residential end uses.

Figure 5-9. Residential Electric Demand Technical Potential by End Use (MW)



Source: Navigant analysis

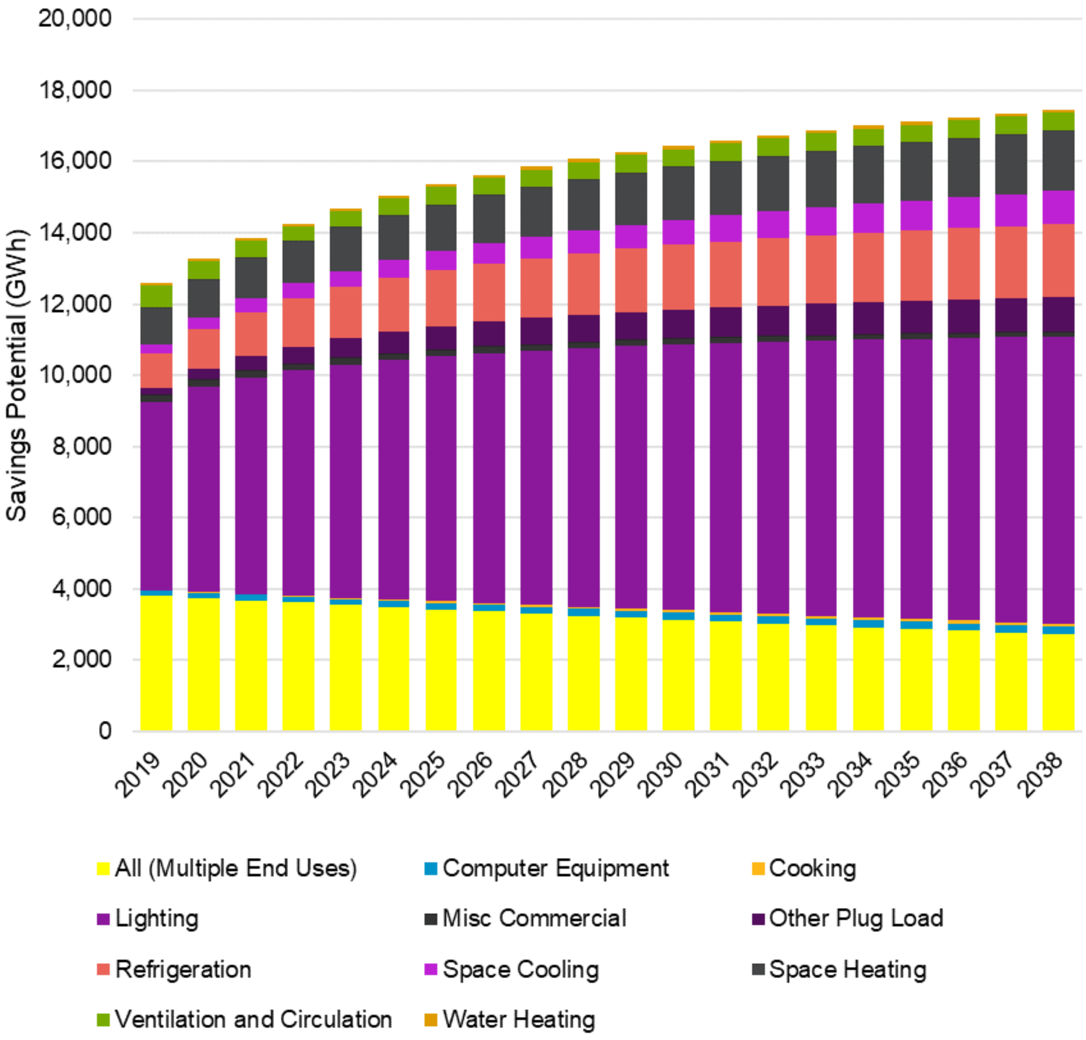
While the electric energy potential was relatively evenly spread among end uses, the space cooling end use completely dominates with respect to electric demand potential. This is due to peak demand being defined as summer demand, during which time space cooling demand is most aligned with the peak consumption period.

Note that that in this case the denominator for the All (Multiple End Uses) end use is total sectoral consumption. Nearly all end uses show potential growing over time as ROB and NEW measures become adopted.

Notable exceptions are the other plug load and miscellaneous residential end uses. In the case of the miscellaneous residential end use this is due to forecast growth in consumption outstripping the growth in potential: the reference forecast predicts an increase in miscellaneous residential loads of 35% between 2018 and 2028.

Figure 5-10 shows the electric energy technical potential across all commercial end uses.

Figure 5-10. Commercial Electric Energy Technical Potential by End Use (GWh)



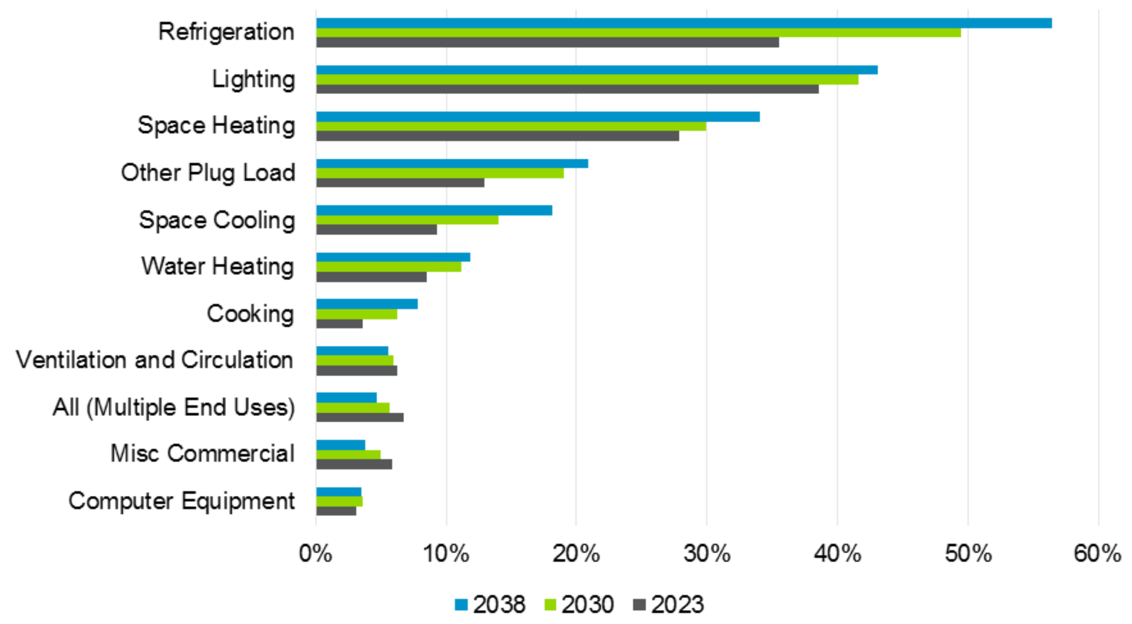
Source: Navigant analysis

Similar to the residential sector, the major opportunity for electricity savings potential in the commercial sector exists in the lighting end use. This is due to the IESO's reference forecast of commercial lighting not predicting any significant natural conservation, suggesting that this market has not yet been transformed and significant opportunity exists. The predicted reduction in commercial lighting intensity between 2018 and 2038 is less than 2%.

The observed decline in the multiple end uses end use potential is a function of building stock turnover, and the fact that it is RET measures that dominate the potential for the commercial sector's end use (e.g., building recommissioning). As building stock turns over, potential associated with the additional insulation installed in older buildings (for example) wanes.

Figure 5-11 shows commercial electric energy savings potential by end use as a percentage of that end use's consumption for three years of the forecast, 2023, 2030, and 2038.

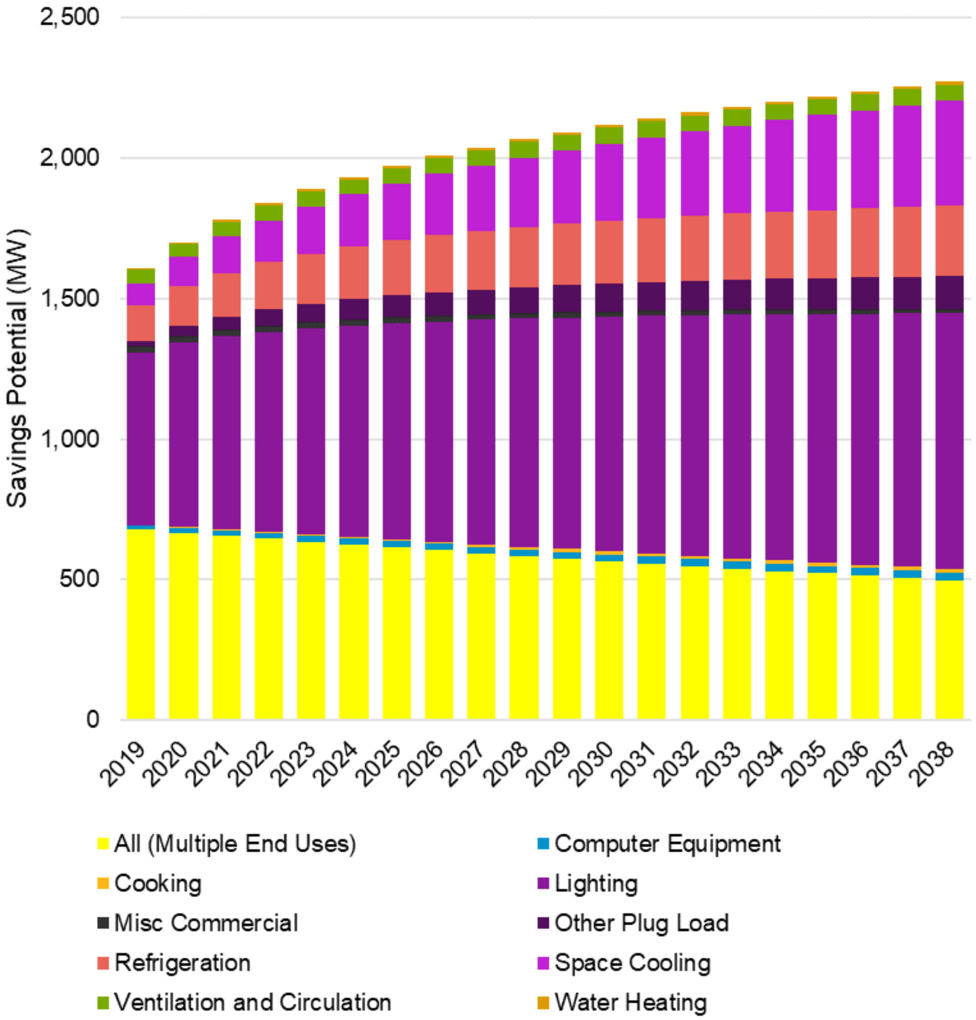
Figure 5-11. Commercial Electric Energy Technical Potential by End Use as a Percentage of End Use Forecast Consumption



Source: Navigant analysis

Figure 5-12 shows the electric demand technical potential across all commercial end uses.

Figure 5-12. Commercial Electric Demand Technical Potential by End Use (MW)



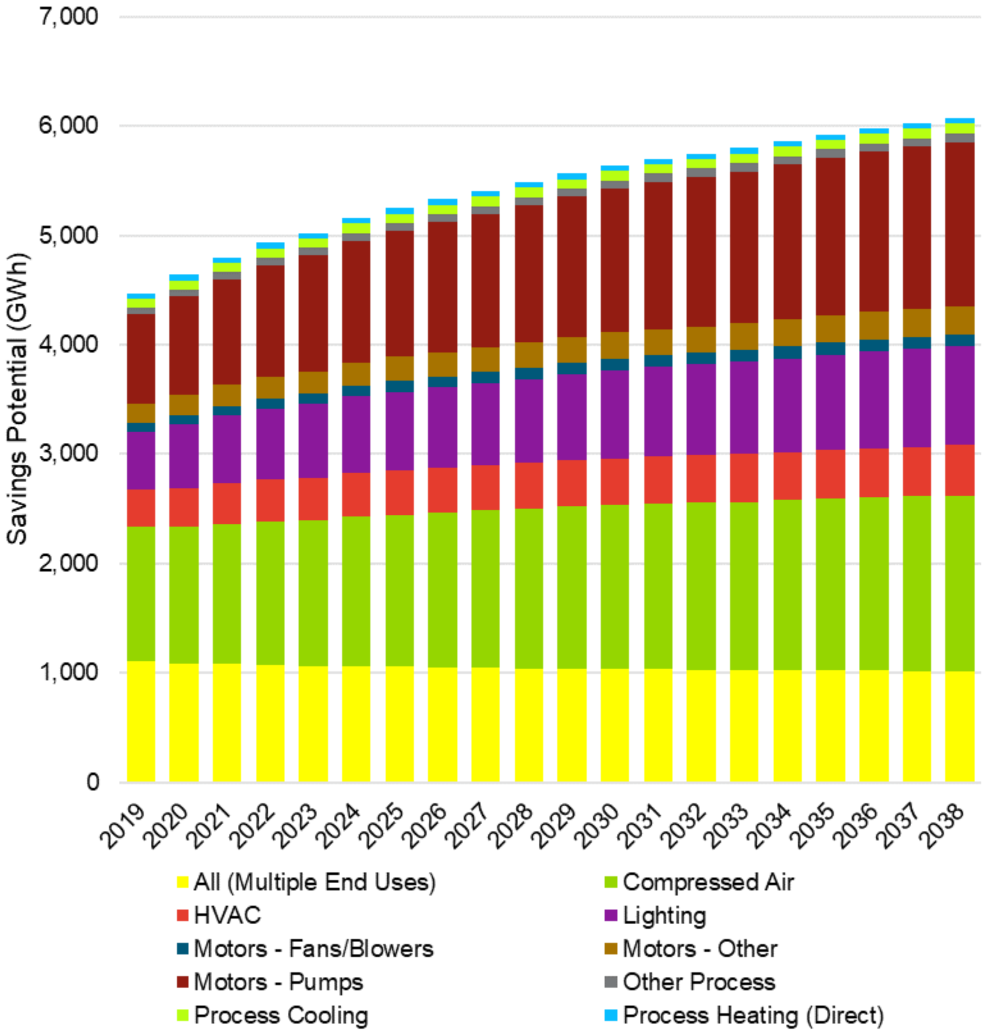
Source: Navigant analysis

Unlike the residential sector, the spread of electric demand potential across end uses was relatively similar to that of the electric energy potential, with the main difference being that space cooling now accounts for a slightly greater percentage of the demand potential. This is due to peak demand being defined as summer demand, during which time space cooling demand is most aligned with the peak consumption period.

As with the residential sector, potential as a percentage of end use consumption increases over time. There are three notable exceptions. The multiple end uses end use declines over time for the reasons noted above. The miscellaneous commercial potential as a percentage of consumption declines for the same reason—a high proportion of the potential associated with that end use derives from RET measures such as variable frequency drives fitted to pumps installed in buildings with less efficient existing systems. The decline in the ventilation and circulation end use is due in large part to interactive effects from natural gas measures that use increased electricity loads to deliver natural gas savings (e.g., heat recovery ventilators).

Figure 5-13 shows the electric energy technical potential across all industrial end uses.

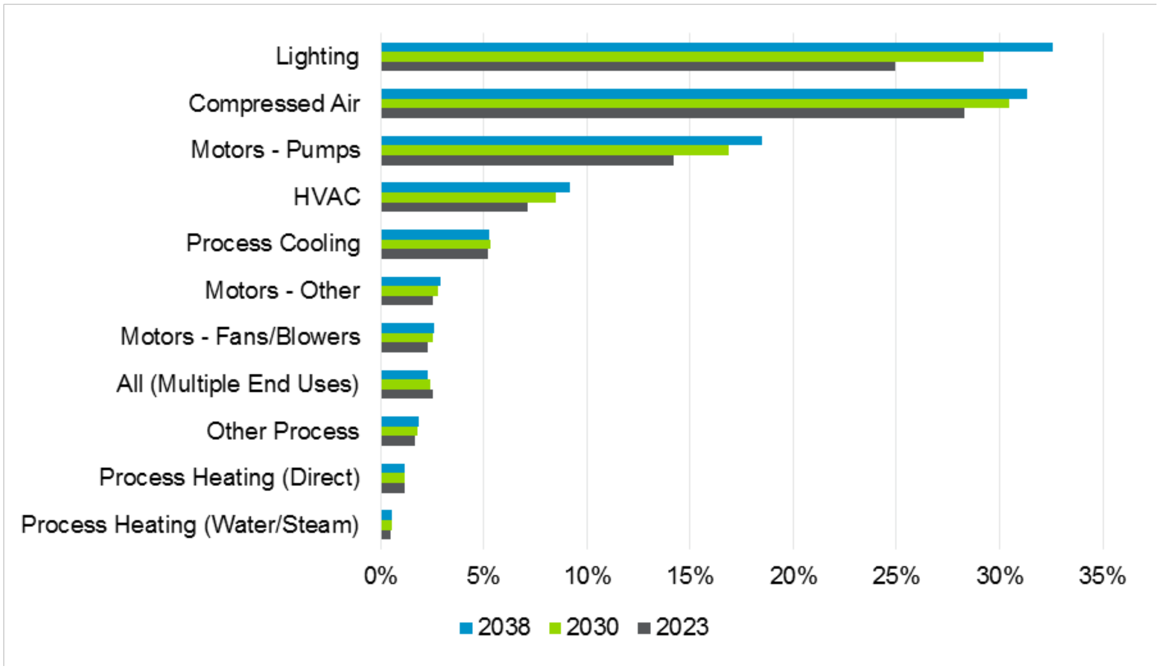
Figure 5-13. Industrial Electric Energy Technical Potential by End Use (GWh)



Source: Navigant analysis

Figure 5-14 shows industrial electric energy savings potential by end use as a percentage of that end use's consumption for three years of the forecast, 2023, 2030, and 2038.

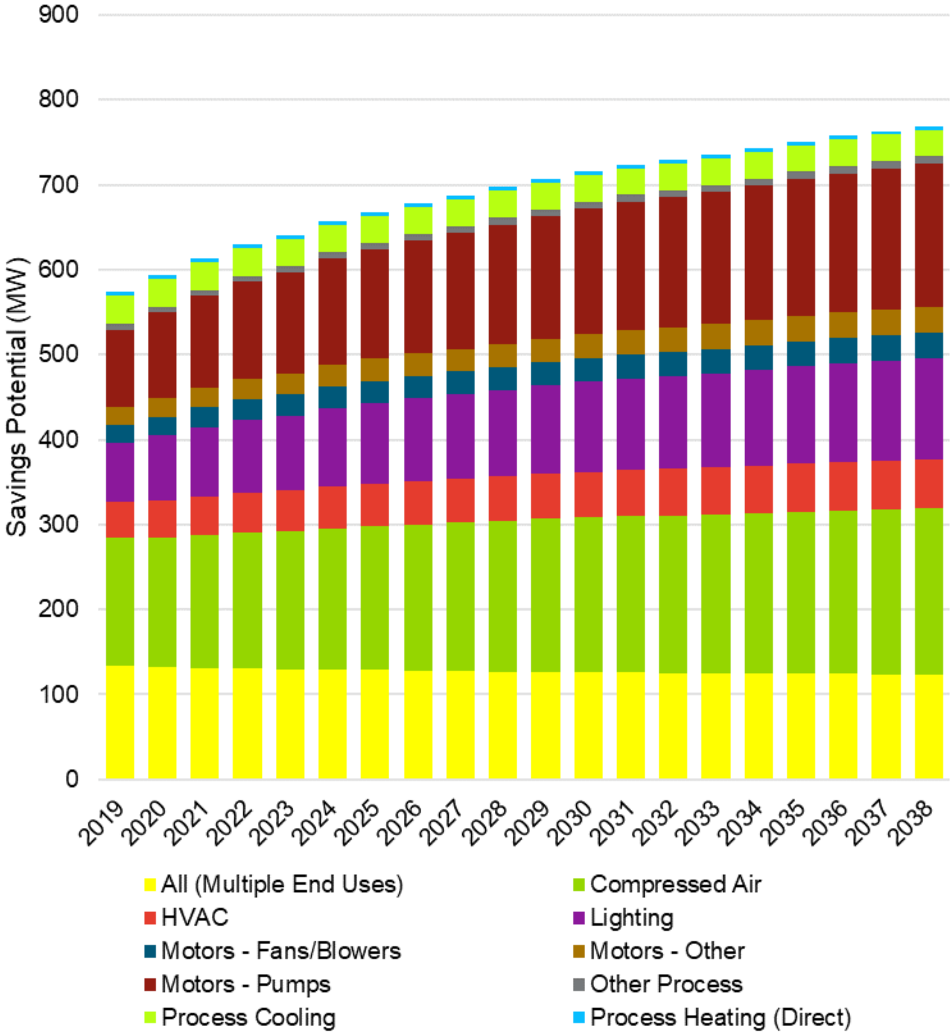
Figure 5-14. Industrial Electric Energy Technical Potential by End Use as a Percentage of End Use Forecast Consumption



Source: Navigant analysis

Figure 5-15 shows the electric demand technical potential across all industrial end uses.

Figure 5-15. Industrial Electric Demand Technical Potential by End Use (MW)

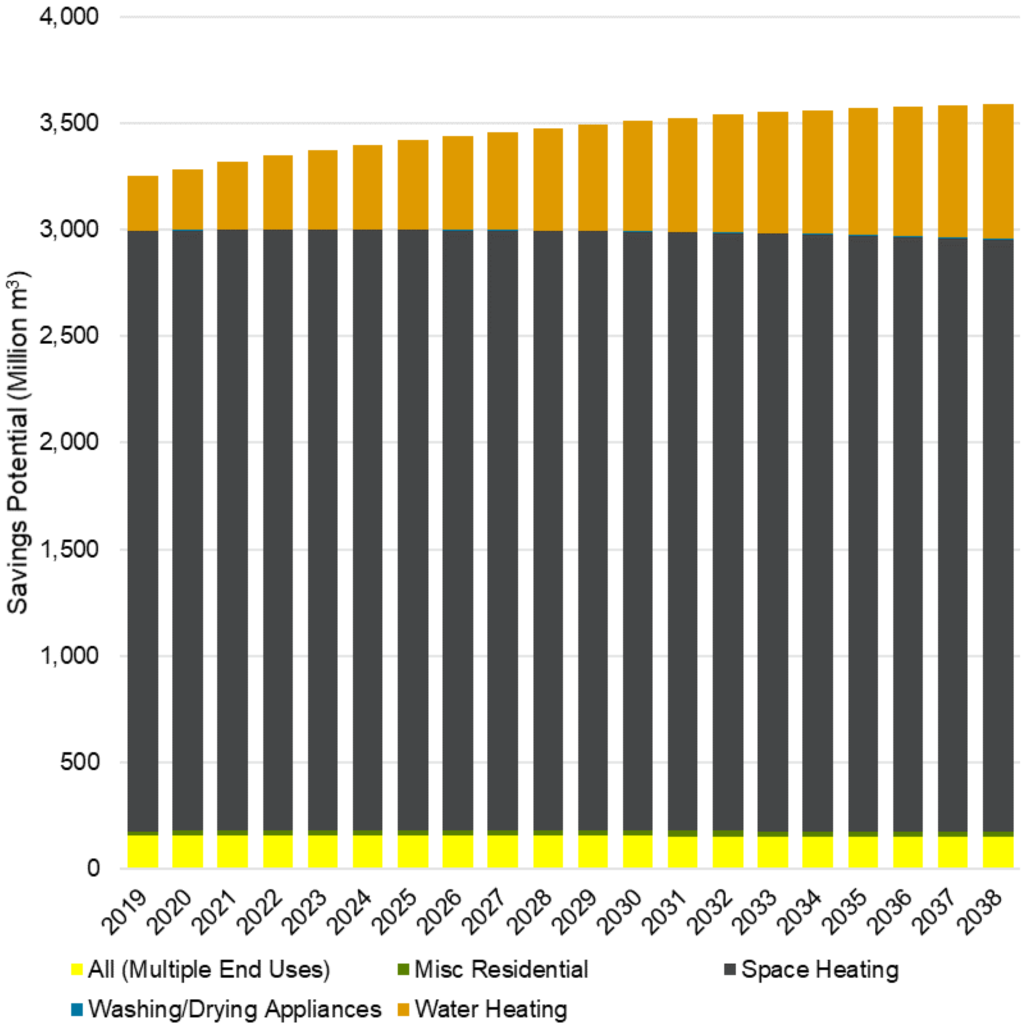


Source: Navigant analysis

Similar to the commercial sector, the spread of electric demand potential across end uses was relatively similar to that of the electric energy potential. There is almost no difference in spread of potential amongst end uses save for slight increases in the process cooling and motors—fans/blowers as a percentage of the total potential. Again, this is due to peak demand being defined as summer demand, during which time cooling needs are most aligned with the peak consumption period.

Figure 5-16 shows the natural gas energy technical potential across all residential end uses.

Figure 5-16. Residential Natural Gas Energy Technical Potential by End Use (Million m^3)

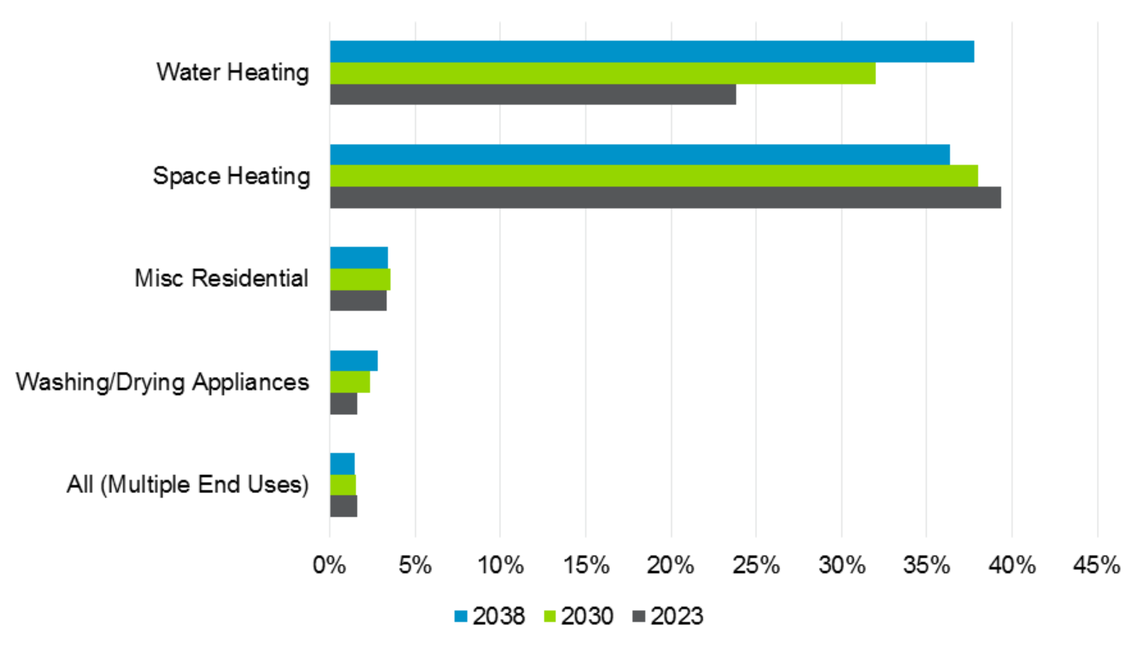


Source: Navigant analysis

As would be expected, given the fuel, the vast majority of technical potential exists in the space heating end use. Approximately three-quarters of total provincial natural gas use in this sector is forecast to be in the space heating end use. The shape of the columns also indicates that savings potential in the residential sector is dominated by opportunities for RET measures (e.g., insulation) over equipment-based ROB and NEW measures, given the already high codes and standards that apply to space heating equipment. Water heating potential, on the other hand, is made up of a more balanced group of measure replacement types – the growth over time in the potential indicates that a substantial portion of ROB or NEW measures – condensing and tankless water heaters.

Figure 5-17 shows residential natural gas energy savings potential by end use as a percentage of that end use's consumption for three years of the forecast, 2023, 2030, and 2038.

Figure 5-17. Residential Natural Gas Energy Technical Potential by End Use as a Percentage of End Use Forecast Consumption

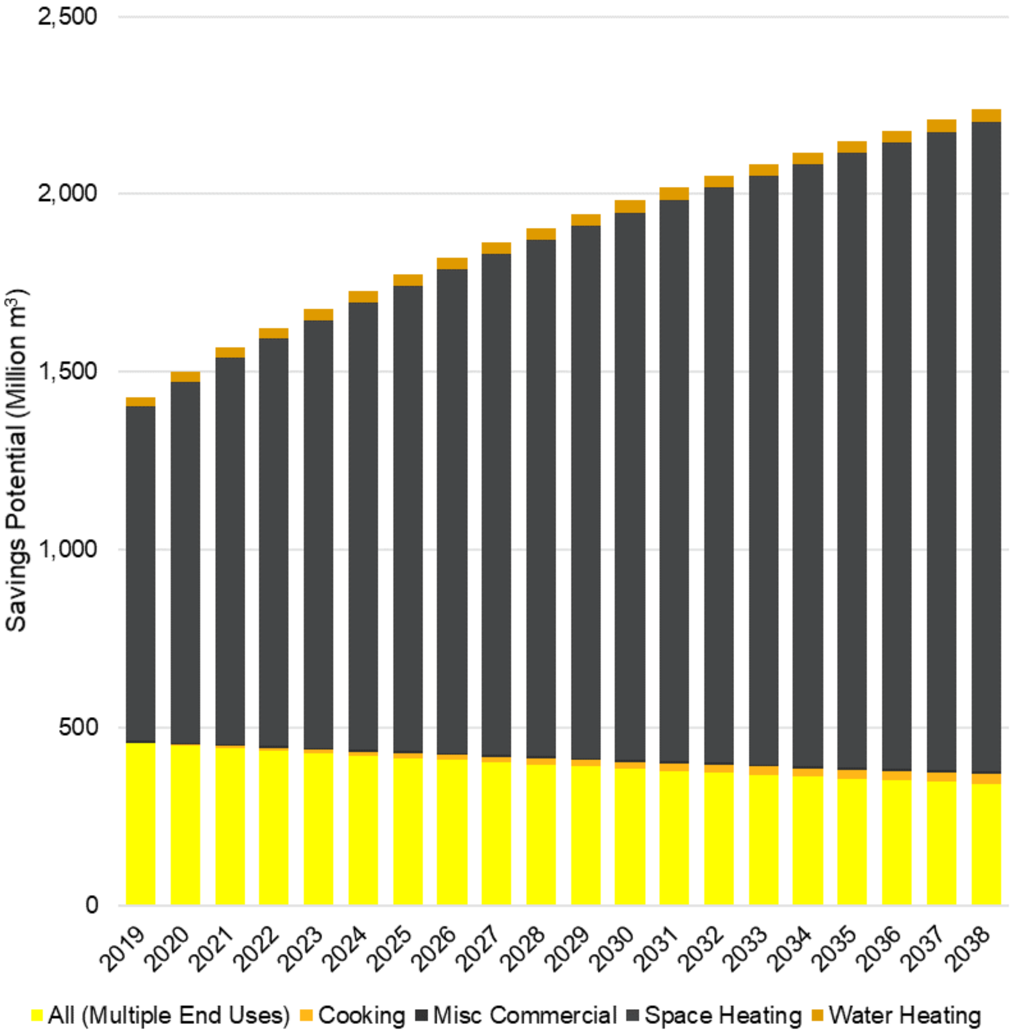


Source: Navigant analysis

As noted above, a very high proportion of residential natural gas space heating potential is derived from RET measures, the savings potential of which would be expected to decline over time (as observed here) as building stock is replaced over time.

Figure 5-18 shows the natural gas energy technical potential across all commercial end uses.

Figure 5-18. Commercial Natural Gas Energy Technical Potential by End Use (Million m^3)

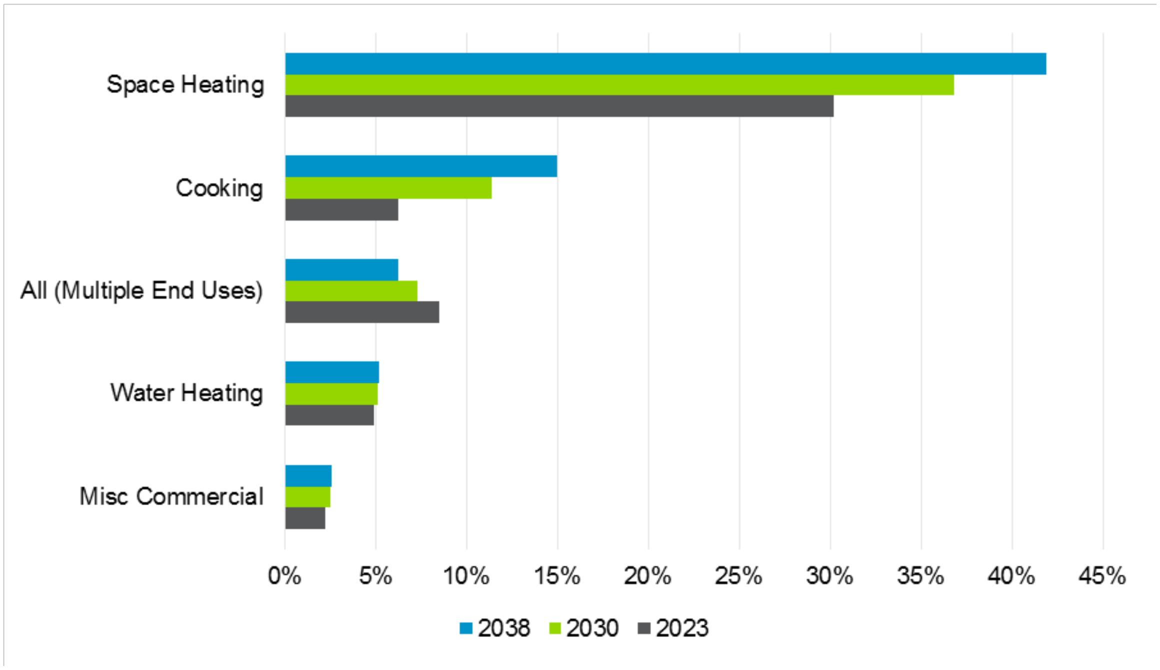


Source: Navigant analysis

As in the case of the residential sector, the vast majority of commercial savings potential is derived from the space heating end use. A significant difference however is that a much higher proportion of the commercial sector potential derives from NEW or ROB measures, in particular condensing boilers and gas-fired rooftop units. As with residential, the potential for the multiple end uses end use (which for this sector mainly accounts for savings derived from the building recommissioning, operations and maintenance improvements measure) declines over time as building stock turns over.

Figure 5-19 shows commercial natural gas energy potential by end use as a percentage of that end use's consumption for three years of the forecast, 2023, 2030, and 2038.

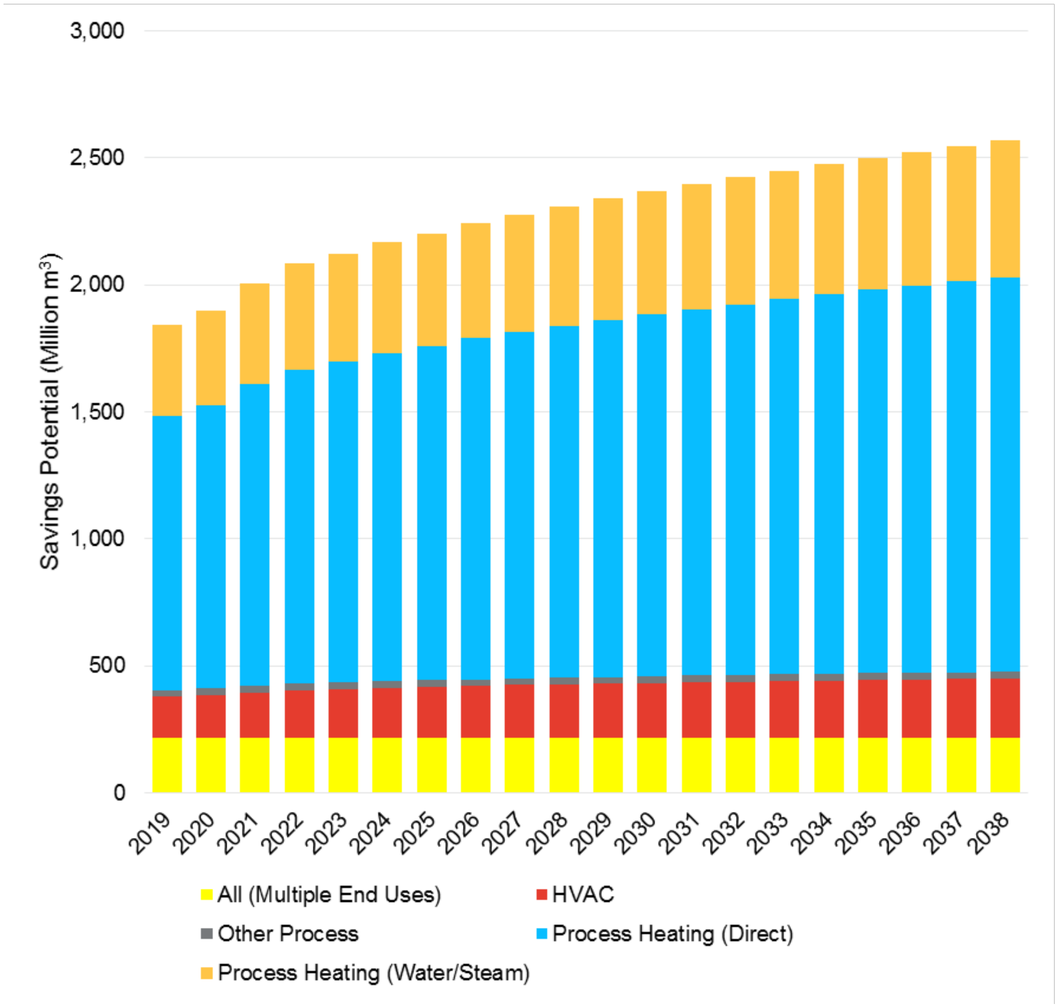
Figure 5-19. Commercial Natural Gas Energy Technical Potential by End Use as a Percentage of End Use Forecast Consumption



Source: Navigant analysis

Figure 5-20 shows the natural gas energy technical potential across all industrial end uses.

Figure 5-20. Industrial Natural Gas Energy Technical Potential by End Use (Million m^3)

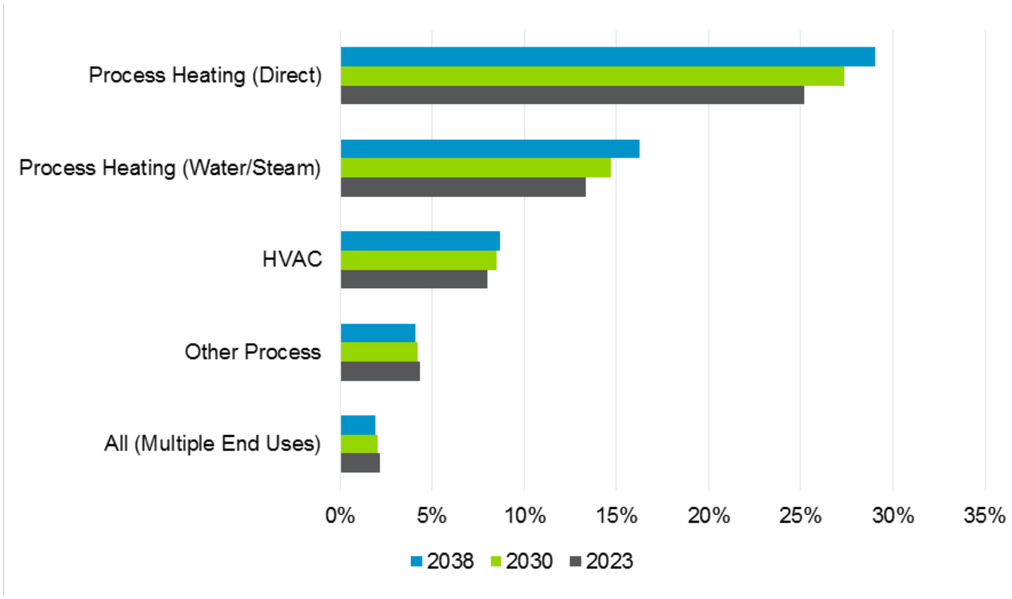


Source: Navigant analysis

As would be expected, given the fuel and sector, the vast majority of technical potential in the industrial sector may be found in the process heating end uses, both direct and water/steam.

Figure 5-21 shows industrial natural gas energy potential by end use as a percentage of that end use’s consumption for three years of the forecast, 2022, 2030, and 2038.

Figure 5-21. Industrial Natural Gas Energy Savings Potential by End Use as a Percentage of End Use Forecast Consumption



Source: Navigant

5.3.3 Results by Measure

The measure-level savings shown in the following tables are after adjustments made to competition groups. In other words, these tables provide only the measures that “won” their respective competition groups. For example, the residential electric measure table lists smart burners (a cooking measure), but not induction cooking stove tops, a competing measure that saves less electricity than the smart burners and, therefore, “loses” when the competition groups are considered. For technical potential, a measure winning its competition group indicates it was the measure with the greatest energy savings in the competition group.

It should be noted that also that these measure-level potential values have not been adjusted for measure stacking, as that step occurs as part of potential aggregation. In addition to providing the annual potential energy savings associated with the cumulative adoption of each measure across the period of projection, each table also provides the proportion of total sectoral potential for which that measure accounts in 2038.

In reviewing the residential measures in Table 5-3, it should be noted that the residential sector includes multifamily buildings, including whole building measures (such as building recommissioning).

Table 5-3 presents the top 20 residential electricity measures in 2038 ranked by technical potential. The top five measures come from the other plug load, lighting, refrigeration, and cooking end uses. Smart power bar ranks as the highest impact technical potential measure.

Table 5-3. Top 20 Measures for Residential Electric Measure-Level Technical Potential in 2038

Measure Rank	Measure Name	Potential (GWh)	% of Pot.
1	Smart Power Bar	1,202	8%
2	ENERGY STAR LED Bulbs General Purpose LEDs	1,176	7%
3	ENERGY STAR A Line, PAR, MR Lamps	1,026	7%
4	ENERGY STAR Refrigerator	1,005	6%
5	Smart Burners	914	6%
6	ENERGY STAR Ground Source Heat Pump	808	5%
7	Ductless Mini-Split Heat Pump	804	5%
8	ENERGY STAR Clothes Washer	801	5%
9	Adaptive Thermostat	700	4%
10	Heat Pump Clothes Dryer	683	4%
11	ENERGY STAR Central Air Conditioner	436	3%
12	Air Sealing	432	3%
13	ENERGY STAR Light Fixture	401	3%
14	Car Block Heater Timer	371	2%
15	Ductless Mini-Split Air Conditioner	369	2%
16	ENERGY STAR Torchiere	326	2%
17	Variable Speed Pool Pump Motor	317	2%
18	Passive Attic Ventilation	256	2%
19	Building Recommissioning, Operations and Maintenance (O&M) Improvements	246	2%
20	ENERGY STAR Windows	234	1%

Note: The names in all measure tables in this document match the model source files to simplify cross-referencing.

Source: Navigant analysis

Table 5-4 presents the top 20 commercial electricity measures in 2038 ranked by technical potential. The top five measures come from the lighting and whole building end uses, with four of the top five measures associated with the lighting end use. Central lighting control system ranks as the highest impact technical potential measure.

Table 5-4. Top 20 Measures for Commercial Electric Measure-Level Technical Potential in 2038

Measure Rank	Measure Name	Potential (GWh)	% of Pot.
1	Central Lighting Control System	2,155	12%
2	Building Recommissioning, Operations and Maintenance (O&M) Improvements	1,732	9%
3	ENERGY STAR LED LAMPS (REFLECTOR LAMPs/MR16/PAR 16)	1,066	6%
4	LED Low/High Bay	1,062	6%

Measure Rank	Measure Name	Potential (GWh)	% of Pot.
5	LED Troffer/Surface/Suspended	865	5%
6	LED Replacement Lamp (Tube)	830	4%
7	High Efficiency Air Source Heat Pump	780	4%
8	Smart Strip Plug Outlets	673	4%
9	LED EXTERIOR AREA LIGHTS - LED fixture (200W)	669	4%
10	Education and Capacity Building/Energy Behavior	652	4%
11	LED parking lot fixture	634	3%
12	Variable Refrigerant Flow Heat Pump	541	3%
13	Refrigerated Display Case Doors	513	3%
14	Furnace Tune-Up	476	3%
15	LED street light fixture	409	2%
16	Reach-in Shaded Pole to ECM/PSC Evaporator Fan Motor	388	2%
17	Demand Control Ventilation	347	2%
18	Advanced BAS/Controllers	340	2%
19	Data Centre Storage/Server Virtualisation	311	2%
20	Strip Curtains	258	1%

Source: Navigant analysis

Table 5-5 presents the top 20 industrial electricity measures in 2038 ranked by technical potential. The top five measures come from the motors – pumps, lighting, and compressed air end uses, with three of the top five measures associated with the compressed air end use. Pump system optimisation ranks as the highest impact technical potential measure.

Table 5-5. Top 20 Measures for Industrial Electric Measure-Level Technical Potential in 2038

Measure Rank	Measure Name	Potential (GWh)	% of Pot.
1	Pump System Optimisation	941	16%
2	HE Lighting	728	12%
3	Air Leak Survey and Repair	612	10%
4	Air Compressor Optimisation	504	8%
5	Efficient Compressed Air Nozzles	487	8%
6	Recommissioning	424	7%
7	SEM (Strategic Energy Management)	424	7%
8	Pump Equipment Upgrade	413	7%
9	High Efficiency HVAC Fans	262	4%
10	Premium Efficient Motors	180	3%
11	Greenhouse Grow Lights	174	3%
12	Process Optimisation (Elec)	171	3%
13	Material Handling Improvements	78	1%
14	HE HVAC Controls	77	1%

Measure Rank	Measure Name	Potential (GWh)	% of Pot.
15	Fan System Optimisation	69	1%
16	Pulp and Paper Process Improvements	65	1%
17	Refiner Plate Improvements	60	1%
18	HE HVAC Units	55	1%
19	Ventilation Optimisation	38	1%
20	Process Heat Recovery	37	1%

Source: Navigant analysis

Table 5-6 presents the top 20 residential natural gas measures in 2038 ranked by technical potential. The top five measures come from the space heating and water heating end uses, with three of the top five measures associated with the space heating end use. Air sealing ranks as the highest impact technical potential measure.

Table 5-6. Top 20 Measures for Residential Natural Gas Measure-Level Technical Potential in 2038

Measure Rank	Measure Name	Potential (Mm^3)	% of Pot.
1	Air Sealing	505	14%
2	Adaptive Thermostat	498	13%
3	Condensing Storage Water Heater	259	7%
4	Tankless Water Heater	218	6%
5	ENERGY STAR Windows	192	5%
6	Condensing Boiler	168	5%
7	Heat Recovery Ventilator	161	4%
8	Comprehensive Draft Proofing	152	4%
9	High Efficiency Condensing Furnace	144	4%
10	High Efficiency Fireplace with Pilotless Ignition	143	4%
11	Wall Insulation	140	4%
12	Attic Insulation	123	3%
13	DHW Recirculation Systems	117	3%
14	Basement or Crawlspace Insulation	105	3%
15	Basement Wall Insulation	103	3%
16	Condensing Make Up Air Unit	99	3%
17	Window Film	72	2%
18	Furnace Tune Up	70	2%
19	Advanced BAS/Controllers	63	2%
20	Ceiling Insulation	52	1%

Source: Navigant analysis

Table 5-7 presents the top 20 commercial natural gas measures in 2038 ranked by technical potential. The top five measures come from the water heating, space heating, and multiple end use end uses, with two of the top five measures associated with the water heating end use. Condensing boiler ranks as the highest impact technical potential measure.

Table 5-7. Top 20 Measures for Commercial Natural Gas Measure-Level Technical Potential in 2038

Measure Rank	Measure Name	Potential (Mm^3)	% of Pot.
1	Condensing Boiler | Std	359	15%
2	Gas Fired Rooftop Units	242	10%
3	Demand Control Ventilation	225	10%
4	Building Recommissioning, Operations and Maintenance (O&M) Improvements	200	9%
5	Boilers - Advanced Controls (Steam Systems)	152	7%
6	Adaptive Thermostats	135	6%
7	Condensing Make Up Air Unit	123	5%
8	Gas Fired Heat Pump	102	4%
9	Advanced BAS/Controllers	78	3%
10	Demand Control Kitchen Ventilation	76	3%
11	Air Handler with Dedicated Outdoor Air Systems	75	3%
12	Condensing Unit Heaters or other Efficient Unit Heating System	72	3%
13	Energy Recovery Ventilation and Ventilation (Enhanced)	69	3%
14	Education and Capacity Building/Energy Behavior	64	3%
15	Steam System Optimisation	40	2%
16	Destratification	38	2%
17	Furnace Tune-Up	38	2%
18	Super-High Efficiency Furnaces (Emerging Tech)	31	1%
19	Heat Recovery Ventilator	29	1%
20	High Efficiency Condensing Furnace AFUE 95% from 80% code	28	1%

Source: Navigant analysis

Table 5-8 presents the top 20 industrial natural gas measures in 2038 ranked by technical potential. The top five measures come from the process heating (direct), process heating (water and steam), and multiple end use end uses, with three of the top five measures associated with the process heating (direct) end use. Process heat improvements ranks as the highest impact technical potential measure.

Table 5-8. Top 20 Measures for Industrial Natural Gas Measure-Level Technical Potential in 2038

Measure Rank	Measure Name	Potential (Mm^3)	% of Pot.
1	Process Heat Improvements	905	35%
2	Boiler Upgrade	350	14%
3	Process Heat Recovery (Gas)	303	12%
4	Recommissioning	218	8%
5	High Efficiency Burners	171	7%
6	Improved Controls -Process Heating Gas	139	5%
7	Greenhouse Envelope Improvements	95	4%

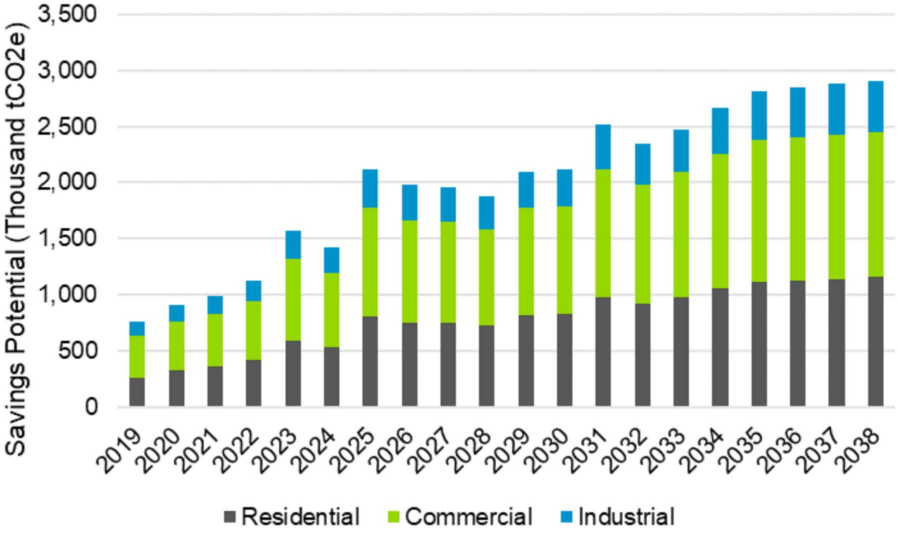
Measure Rank	Measure Name	Potential (Mm³)	% of Pot.
8	Boiler Tune Up	43	2%
9	High Efficiency HVAC Fans (Gas)	43	2%
10	Insulation - Steam	42	2%
11	VAV Conversion Project (Gas)	35	1%
12	Direct Contact Water Heaters	31	1%
13	Steam Leak Repairs	26	1%
14	HE HVAC Controls	24	1%
15	Loading Dock Seals	24	1%
16	Steam Trap Repair	20	1%
17	High Efficiency Furnaces	20	1%
18	Insulation - Steam (AG)	18	1%
19	Air Compressor Heat Recovery	15	1%
20	Steam Turbine Optimisation	10	0%

Source: Navigant analysis

5.3.4 Emissions Reductions Results

Figure 5-22 shows the total electric energy technical emissions savings potential for each sector. The general trend can be found to track the potentials of each sector, with the drops in 2024, between 2025 and 2028, and in 2032 being due to the forecast decline in the emissions intensity (as seen in Figure 5-23) of electricity being greater than the growth of potential in those years. The forecast electric energy emissions intensities were generated using the 2018 Technical Planning Conference data[47].

Figure 5-22. Electric Technical Emissions Reduction Potential by Sector (Thousand tCO2e)

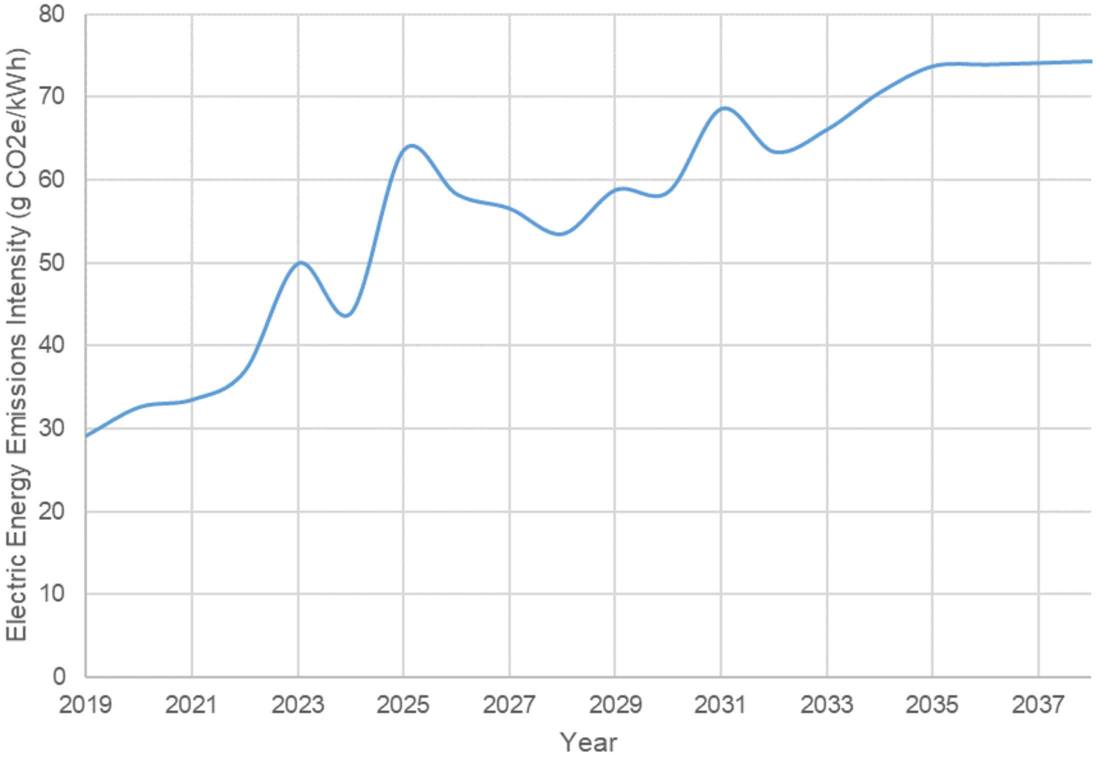


---

[47] 2018 Technical Planning Conference data available here: http://www.ieso.ca/-/media/Files/IESO/Document-Library/planning-forecasts/tech-conf/2018-Technical-Planning-Conference-Data--0181129.xlsx?la=en

Source: Navigant analysis

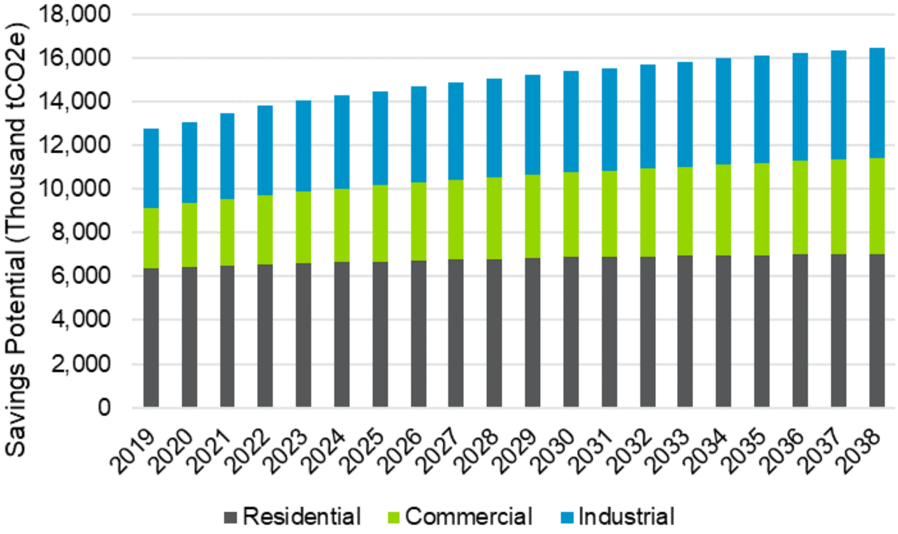
Figure 5-23. Electricity Emissions Intensity



Source: Navigant analysis

Figure 5-24 shows the total natural gas energy technical emissions savings potential for each sector. Given that the emissions intensity of natural gas does not change over time, the trend of abated emissions directly tracks the growth of technical potential over time.

Figure 5-24. Natural Gas Emissions Reduction Savings Potential by Sector (Thousand tCO2e)



Source: Navigant analysis

6. ECONOMIC POTENTIAL

This section describes the economic potential, which is the cost-effective potential for energy efficiency and fuel switching available in Ontario. Please note that this chapter focuses on the results of the energy efficiency measures; the fuel switching results can be found in the Appendix E.1.2.

The objective of the economic potential task was to provide an estimate of the economically feasible energy conservation potential in Ontario across the 20-year reference forecast period covered by the potential study. The economic potential is a subset of technical potential and provides a value of the projected achievement of future conservation efforts constrained by considerations of cost-effectiveness. This does not consider consumer behaviour or adoption rates (these factors are captured by the achievable potential scenarios). The economic potential outputs from Navigant's model were driven by inputs provided by the measure characterisation task as well as factors that determine cost-effectiveness such as avoided electricity (energy and demand) and natural gas costs.

This chapter of the report is divided into three sections:

1. **Scope:** Defines the key outputs generated as part of the economic potential analysis.
2. **Methodology:** Provides a high level description of the key assumptions and analytic approaches used to estimate the economic potential. Additional detail on select methods may be found in Appendix E.
3. **Results:** Provides a summary of the results of the economic potential estimation.

6.1 Scope

When calculating economic potential, Navigant estimated savings potential for the cost-effective measures including annual electricity energy and demand, and natural gas as well as the associated carbon savings and cost estimates for 2019-2038. Economic potential is calculated by zone, sector, segment, and end use, and assumes that 100% of customers implement all applicable cost-effective measures, regardless of consumer behaviour and adoption. The electric economic potential utilised electricity load shapes to determine hourly coincident peak demand savings and annual energy savings (economic potential). A more detailed discussion of the peak demand savings values is provided in Chapter 5. In addition to the considerations introduced in the Technical Potential chapter, the estimation of economic potential addresses the following considerations (see Section 6.2 section for more details):

- **Cost-effectiveness.** The ratio of benefits to costs of a measure as compared to a cost-effectiveness threshold. If the benefit to cost ratio is greater than the threshold then the measure is considered cost-effective.
- **Measure replacement types.** Measures may be installed at the time of building construction (NEW), after construction but before the end of the measure's useful life (RET) or at the end of a measure's useful life (ROB).
- **Competing measures.** Cases in which two or more mutually exclusive measures exist (e.g., storage water heaters and tankless water heaters).
- **Persistence and market transformation.** The assumption that programmatically-driven measure adoption moves the market forward, resulting in consumers replacing their efficient measures on a like-for-like basis at the end of their expected useful life.
- **Interactive effects.** Some measures impact both electricity and natural gas potential in opposite directions. For example, a heat recovery ventilator reduces natural gas space heating consumption but increases electric ventilation consumption.

- **Measure stacking.** When two measures that share the same end use are installed at the same time, the total savings of the two combined may be less than the sum of their individual savings. For example, adding insulation to a home and replacing the furnace will deliver an aggregate savings that is less than the savings of these two measures on their own.

More specifically, the key outputs of this analysis are:

- **Electric energy economic potential (GWh)** from energy conservation measures.
- **Cost-effectiveness values (Electric only and dual fuel measures)**
- **Natural gas economic potential (millions of m^3)** from energy conservation measures.
- **Cost-effectiveness values (Natural gas only and dual fuel measures)**
- **Electric peak demand economic potential (MW)** from energy conservation measures.
- **GHG emissions reductions (Mt CO2e)** associated with the economic potential values cited above.
- **Fuel switching economic potential.** Natural gas economic potential and electric energy incremental consumption from fuel switching measures.
- **The electric DR potential (MW)** associated with technically feasible adoption of electric energy conservation measures considered in this study. Only those energy conservation measures that may be remotely controlled by a program administrator after only minor modifications are made are considered for this output.[48]

In addition to generating the economic potential results, additional deliverables included discussing the results and benchmarking comparisons with the Project Team and Advisory Group for feedback, and to summarise the methodology, data sources, and results in the final report.

6.2 Methodology

The following sections of this chapter provide additional detail regarding aspects of the methodology highlighted in second half of Section 5.1; specifically, it addresses:

- Cost-Effectiveness
- Avoided Costs
- Competing Measures
- Measure Stacking

6.2.1 Cost-Effectiveness

Economic potential is a subset of technical potential that uses the same assumptions regarding immediate replacement as in technical potential but includes only those measures that have passed the benefit-cost test chosen for measure screening. This measure screen is performed at the most granular level (every combination of measure, segment, sector and zone).

---

[48] The approach and findings related to this output may be found in Appendix E.

This study uses the Total Resource Cost (TRC) test,[49] known as the TRC-plus, to screen for cost-effectiveness. The TRC-plus ratio for each measure is calculated each year and compared against the measure-level TRC-plus ratio screening threshold of 1.0. A measure with a TRC-plus ratio greater than or equal to 1.0 is a measure that provides monetary benefits greater than or equal to its costs. If a measure's TRC-plus meets or exceeds the threshold, it is included in the economic potential.

The TRC-plus test is a benefit-cost ratio comparing the net benefits of energy efficiency measures from a societal perspective, because it considers the costs and benefits to all stakeholders including the utility (or program administrator) and its customers. The TRC-plus benefit-cost ratio is calculated in the model using the following equation:

Equation 6-1. Benefit-Cost Ratio for Total Resource Cost Plus Test

$$TRC - plus = \frac{PV(Avoided\ Costs\ (Including\ 15\%\ Non - Energy\ Benefit\ Adder) + O\&M\ Savings)}{PV(Measure\ Cost)}$$

Where:

- *PV* is the present value calculation that discounts cost streams over time.
- *Avoided Costs* are the monetary benefits resulting from commodity (electricity and natural gas), capacity costs and distribution costs e.g., avoided costs of infrastructure investments, as well as avoided (commodity costs) due to energy conserved by efficient measures). In addition, this includes a 15% adder that accounts for the non-energy benefits associated with DSM programs, such as environmental, economic, and social benefits.
- *O&M Savings* are the non-energy benefits such as operation and maintenance cost savings.
- *Measure Cost* is the incremental equipment cost to the customer.

Navigant calculated TRC-plus ratios for each measure based on the present value of benefits and costs (as defined above) over each measure's life to determine whether it was cost-effective or not.

Although the TRC-plus equation includes administrative costs, the potential study does not consider these costs during the economic screening process because those costs are largely driven by program design, which is outside of the scope of this evaluation.

Regarding the calculation of cost-effectiveness for fuel switching measures, an additional nuance should be noted. Given that all fuel switching measures in this study switch from consuming natural gas to electricity, the avoided costs of each fuel type must be considered. Given that the measures reduce their natural gas consumption to zero, the avoided natural gas costs are a benefit. However, since these measures result in an increase of electricity consumption, the avoided cost of electricity is negative, making it a cost. Both of these value streams are considered in the calculation of a fuel switching measure's cost-effectiveness. A measure's gas and electric avoided costs are summed together, at which point if they are positive they remain as a benefit in the numerator of the TRC-plus. However, if the sum of the avoided costs for a measure are negative they are considered a cost and moved to the denominator of the TRC-plus.

6.2.2 Avoided Costs

Given the differences in who provides the energy and how it is valued, the avoided costs of natural gas and electricity were developed using unique approaches as described below:

---

[49] The TRC-plus is the same version of the TRC cost test that was used in the OEB's previous natural gas potential study.

Natural Gas Avoided Costs: Avoided costs were provided by both Union Gas and Enbridge. To arrive at a single value that could be used within shared zones, these values were weighted by their respective consumption as a percent of the total provincial consumption. These values were then averaged to arrive at a combined avoided cost of natural gas. Next, the 15% adder that accounts for the non-energy benefits associated with DSM programs, such as environmental, economic, and social benefits was added in. Finally, the cost of carbon as defined by the Greenhouse Gas Pollution Pricing Act[50] was included.

Electricity Avoided Costs: Avoided costs were provided by the IESO for both electric energy and demand. The electric energy avoided costs were provided for each of the following peak period definitions:

- Winter On-Peak
- Winter Off-Peak
- Winter Mid-Peak
- Summer On-Peak
- Summer Off-Peak
- Summer Mid-Peak
- Shoulder Mid-Peak
- Shoulder Off-Peak

The electric energy avoided costs include a 15% adder to capture non-energy.

6.2.3 Competing Measures

To address the overlapping nature of measures within a competition group, Navigant's analysis only selects one measure per competition group to include in the *summation* of economic potential across measures (e.g., at the end use, consumer segment, sector, service territory, or total level). For the economic potential estimation, the measure selected as the winner of the competition group is the measure that has a TRC-plus greater than or equal to 1 and delivers the largest volume of savings in the given year. If all measures in a competition group pass the TRC-plus test, then the measure with the largest volume of savings (not the measure with the highest TRC-plus) is selected as a winner of the competition group. This approach ensures that the aggregated economic potential does not double-count savings. However, the model still calculates the economic potential for each individual measure outside of the summations. The economic potential (pre-competition groups and pre-measure stacking may be found in Appendix E.

The treatment of measure interactive effects has not changed from the definition provided in Section 5.2.4. As a reminder, interactive effects are different than measure stacking, as discussed below.

6.2.4 Measure Stacking

As discussed in Section 5.2.5 and Appendix D.1.1, when two or more measures that impact the same end use energy consumption are installed in the same building, the total savings that can be achieved may be less than the sum of the savings from those measures independently. For example, consider a high efficiency boiler and ceiling insulation. If both are installed together in the same building, the total savings would be less than the sum of the individual measure savings: the installation of the more

---

[50] https://laws-lois.justice.gc.ca/eng/acts/G-11.55/page-41.html#h-74

efficient boiler reduces the amount of natural gas required to satisfy a given thermal load, but the installation of the ceiling insulation reduces the thermal load itself.

The only difference between the technical and economic potential after considering measure stacking is that only cost-effective measures are included. No additional considerations were made for evaluating the effects of measure stacking at the economic potential stage. For example, it was assumed that most consumers do not calculate the marginally reduced benefits of installing lighting controls and more efficient lighting prior to purchasing both, and thus no adjustment to the cost-effectiveness of stacking measures was made.

6.3 Results

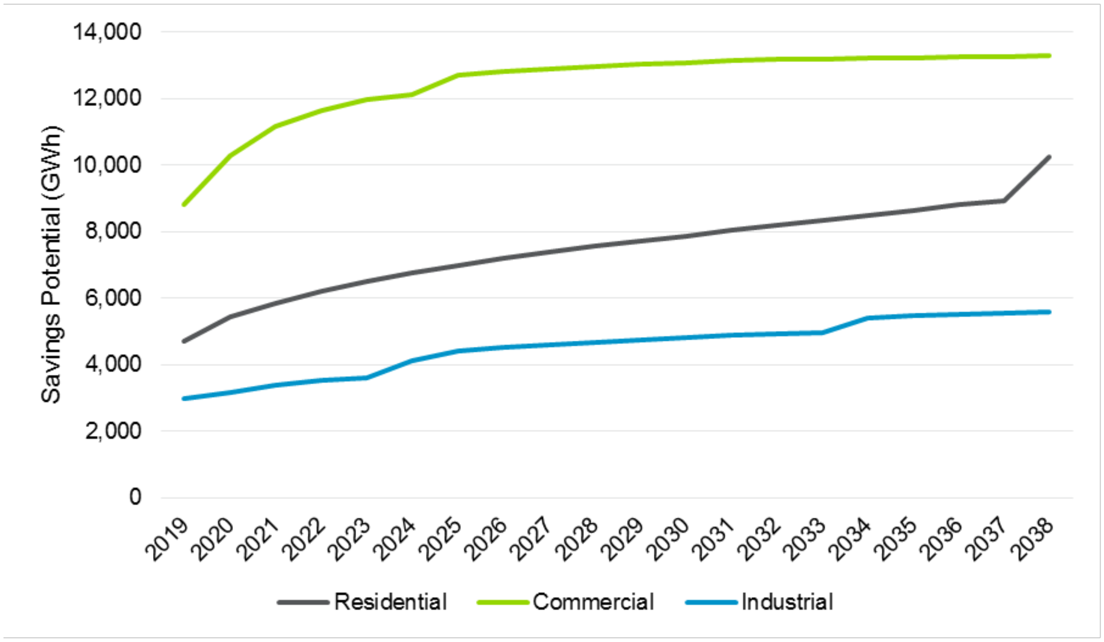
This sub-section provides DSMSim results pertaining to total economic potential at different levels of aggregation, reported at the meter. The economic potential of energy efficiency measures is shown by sector, end use category and for measures with the highest potential. The associated sectoral potential emissions reductions are also provided.

Additional outputs, including energy efficiency potential by segment, fuel switching technical potential, and the technically feasible DR potential associated with energy efficiency measures are shown in Appendix E. This appendix also provides the energy efficiency technical potential results benchmarked against the values estimated in the 2016 Natural Gas Conservation Potential Study and by other publicly available potential studies are provided.

6.3.1 Results by Sector

Figure 6-1 shows the total electric energy economic potential for each sector. The average rate of economic potential growth by sector over the potential reference forecast period is similar to the average rate of technical potential growth. In certain years, step increases in economic potential are driven by measures that were previously not cost-effective becoming cost-effective and providing potential. In general, this is due to a combination of avoided costs increasing and some measure costs decreasing. For example, the 2037 to 2038 residential potential increase was the result of smart power bars becoming cost-effective due to the increasing electric avoided costs finally overtaking the incremental measure costs.

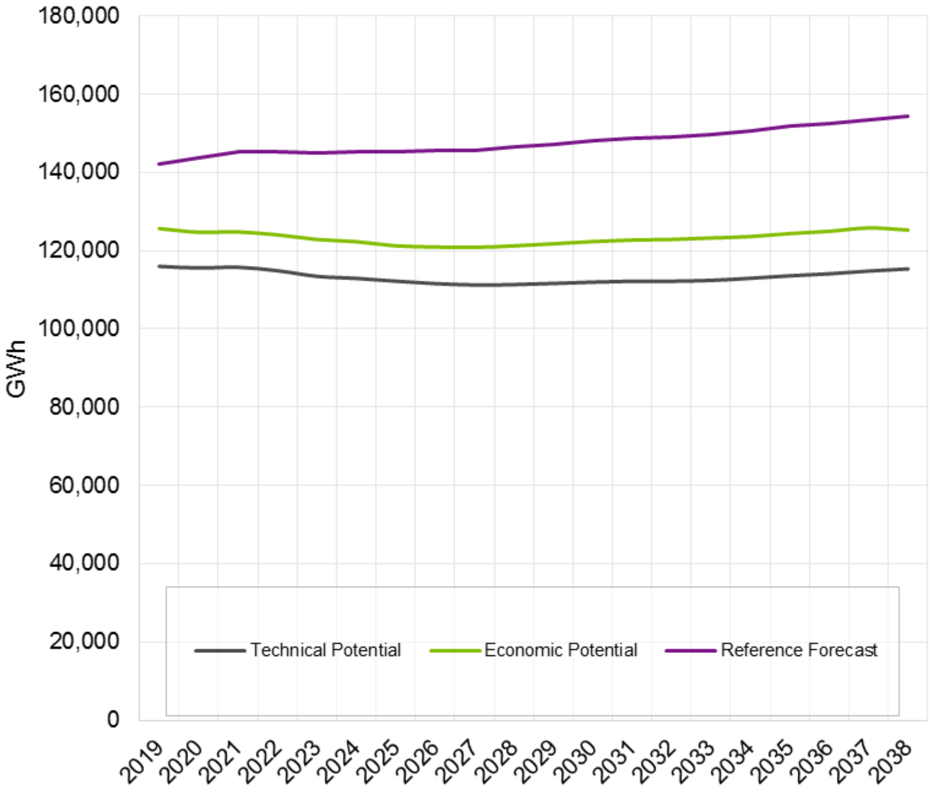
Figure 6-1. Electric Energy Economic Potential by Sector (GWh)



Source: Navigant analysis

Figure 6-2 contrasts the estimated electric economic potential across the potential reference forecast period with the total forecast consumption over the same period. The reference forecast less economic potential follows the same trend as the reference forecast less technical potential.

Figure 6-2. Electric Energy Reference Forecast and Economic Potential



Source: Navigant analysis[51]

Table 6-1 provides the estimated economic potential as a percentage of total forecast consumption for three years of the reference forecast period, both by sector, and for the province as a whole.

Table 6-1. Electric Energy Economic Potential as a Percentage of Forecast Consumption

Year	Residential	Commercial	Industrial	Total
2023	13%	23%	8%	**15%**
2030	16%	24%	11%	**17%**
2038	20%	23%	13%	**19%**

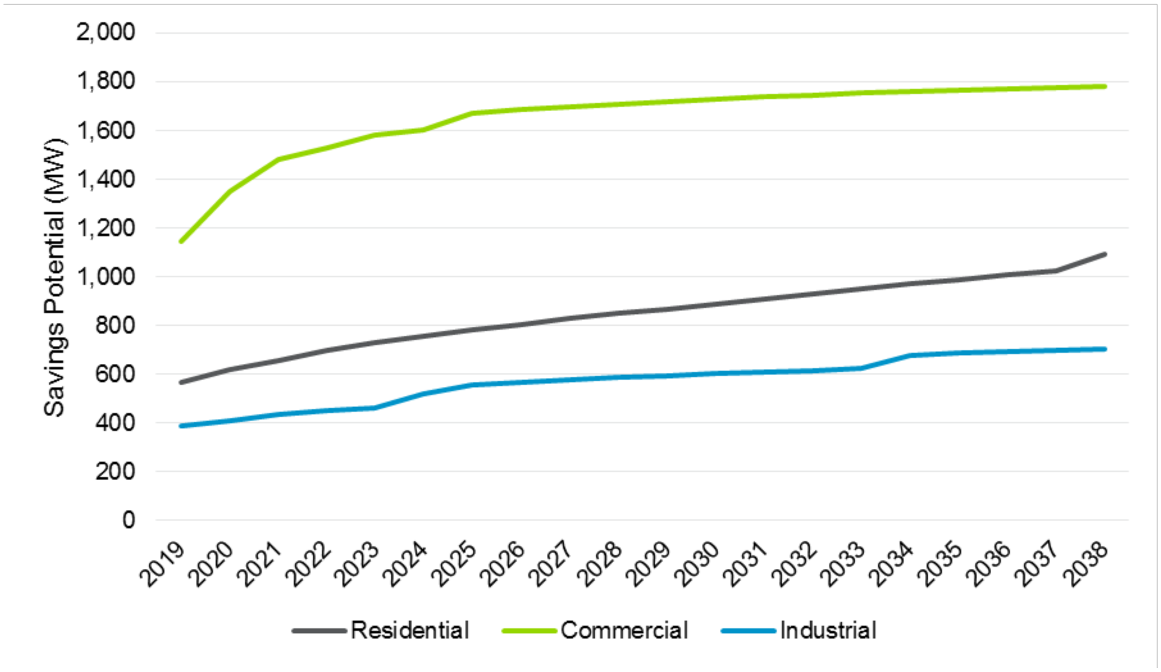
Source: Navigant analysis

---

[51] Although the figure displays what is referred to as the technical and economic potentials, the actual technical and economic potential values can be calculated as the difference between the potential curve and the reference forecast curve.

Figure 6-3 shows the total electric summer peak demand economic potential for each sector. Similar to the electric energy economic potential, the electric demand economic potential of each sector grew at a similar rate to its technical potential, with a few small stepwise increases between consecutive years that are discussed in the sectoral results below.

Figure 6-3. Electric Summer Demand Economic Potential by Sector (MW)

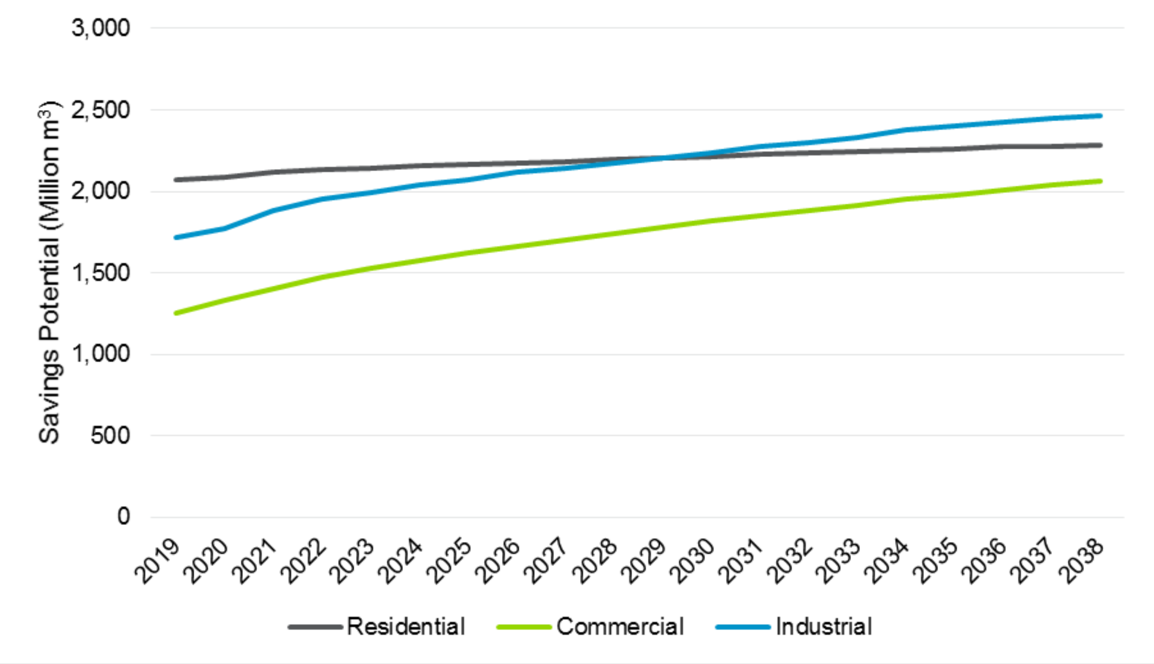


Source: Navigant analysis

The summer peak demand potential cannot be contrasted with the reference forecast in the same manner as the electric energy potential because there is no correspondingly granular forecast of peak demand (i.e., by segment, end use, etc.).

Figure 6-4 shows the total natural gas energy economic potential for each sector. The economic potential of the commercial and industrial sectors grew at similar rates to their technical potential. The residential sector saw a large decrease from technical to economic potential due to several measures with high technical potential, such as condensing storage water heaters and energy star windows (two of the top five measures in technical potential), not being cost-effective in most or all of the years, customer segments, and service territories.

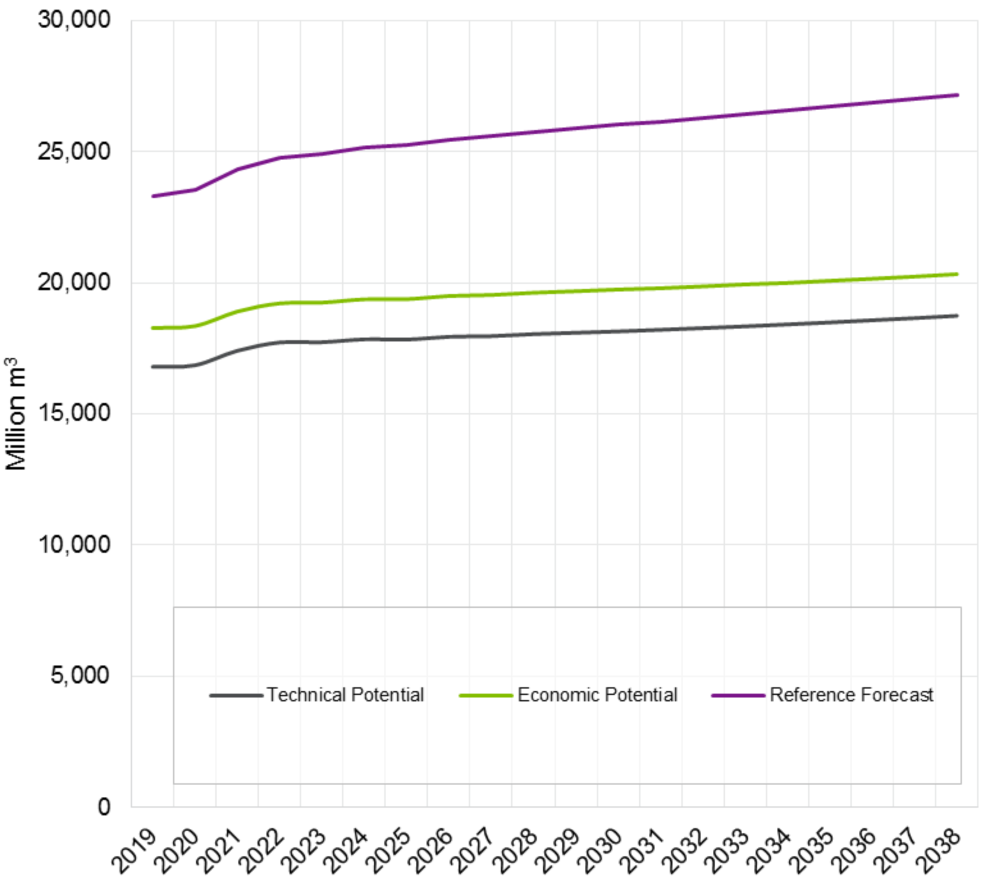
Figure 6-4. Natural Gas Economic Potential by Sector (Million m^3)



Source: Navigant analysis

Figure 6-5 contrasts the estimated natural gas economic potential across the reference forecast period with the total forecast consumption over the same period. The reference forecast less economic potential follows the same trend as the reference forecast less technical potential.

Figure 6-5. Natural Gas Reference Forecast and Economic Potential



Source: Navigant analysis[52]

Table 6-2 provides the estimated economic potential as a percentage of total forecast consumption for three years of the reference forecast period by sector and for the province as a whole.

Table 6-2. Natural Gas Energy Economic Potential as a Percentage of Forecast Consumption

Year	Residential	Commercial	Industrial	Total
2023	22%	30%	20%	**23%**
2030	22%	35%	21%	**24%**
2038	22%	38%	22%	**25%**

Source: Navigant analysis

---

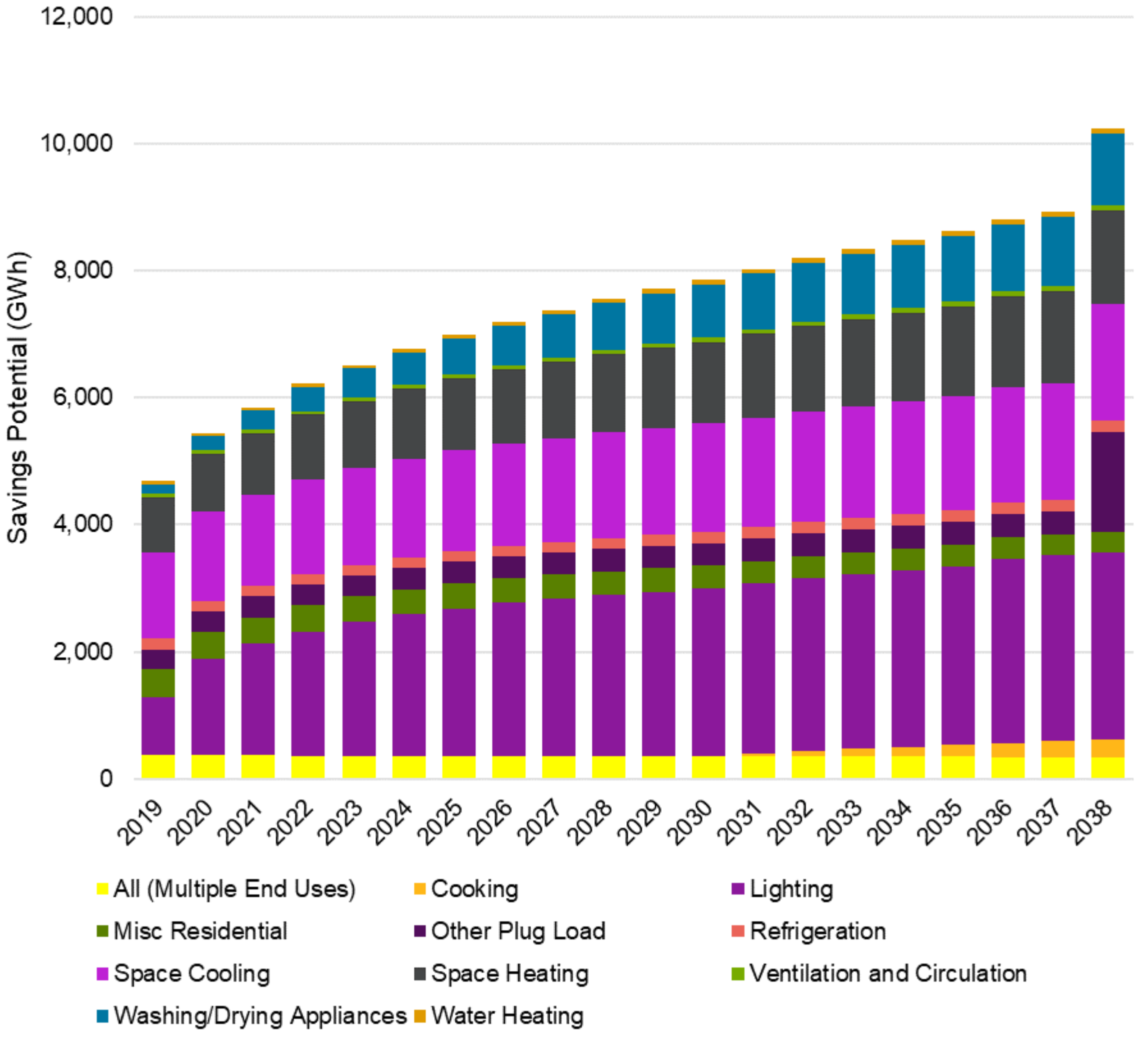
[52] Although the figure displays what is referred to as the technical and economic potentials, the actual technical and economic potential values can be calculated as the difference between the potential curve and the reference forecast curve.

6.3.2 Results by End Use and Sector

This sub-section of the results section presents end use potential by sector. For each sector and fuel, the time-series of energy savings potential is presented in energy units. Likewise, for each sector and fuel, end use potential as a percentage of that end use's forecast consumption is presented for three indicative years.

Figure 6-6 shows the electric energy economic potential across all residential end uses. The All (Multiple End Uses) end use captures savings from measures that deliver savings across a variety of end uses, measures such as home energy reports and building recommissioning (multifamily, or multi-res, residential buildings only).

Figure 6-6. Residential Electric Energy Economic Potential by End Use (GWh)



Source: Navigant analysis

The average rate of economic potential growth by end use over the potential reference forecast period is similar to the average rate of technical potential growth except for the other plug load end use. This was the result of the smart power bar not being cost-effective for all years except 2038, where it can be seen the economic potential increases for the other plug load end use in 2038. Cooking measures do not become cost-effective until 2031, at which point the growth trend follows that seen in technical potential. In each case, this is due to the relative increase in avoided costs overtaking the incremental costs of the measure in the given year.

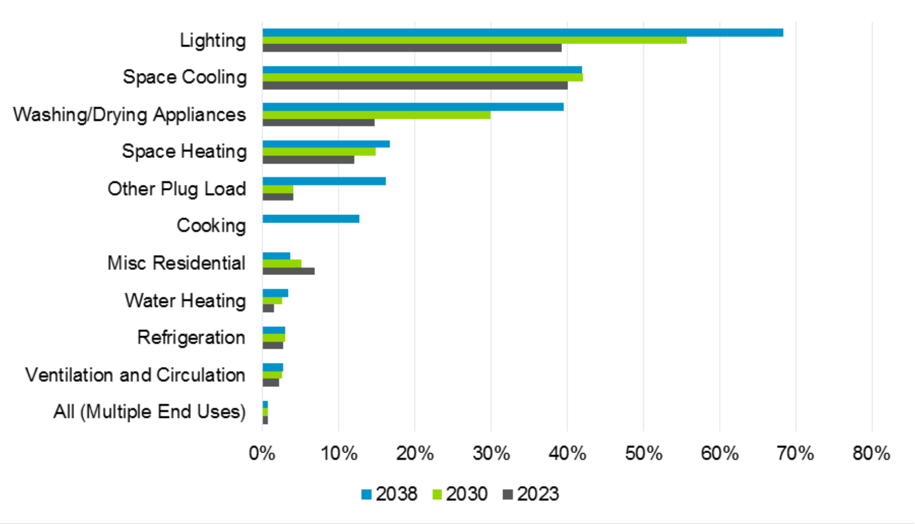
Similar to technical potential, the residential end uses with the most economic potential include space cooling, space heating, and lighting. The main difference is that the potential from the other plug loads end use is no longer a top producer of potential until 2038.

As can be seen in the figure above, a very high proportion of economic space heating potential is driven by the deployment of RET measures (air sealing, basement insulation, etc.) in the early years of the potential study. This is due to the majority of stock in the early years being existing stock, and it takes time for new stock to come online (needed for NEW measure potential) or for this existing stock to burn out and become eligible for replacement (required for ROB measure potential). In 2023, 95% of space heating potential is derived from RET measures. The turnover of building and equipment stock, however, results in an increasing share (20%) of the potential being delivered by ROB and NEW measures (heat pumps) by 2038.

Water heating potential is very low in all years. This is due to the very high level of natural conservation anticipated by the IESO reference forecast[53]—between 2019 and 2038, the reference forecast anticipates a 55% reduction in water heating electricity intensity.

Figure 6-7 shows residential electric energy savings potential by end use as a percentage of that end use's consumption for three years of the forecast, 2023, 2030, and 2038.

Figure 6-7. Residential Electric Energy Economic Potential by End Use as a Percentage of End Use Forecast Consumption[54]



Source: Navigant analysis

Nearly all end uses show potential growing over time as ROB and NEW measures become adopted.

---

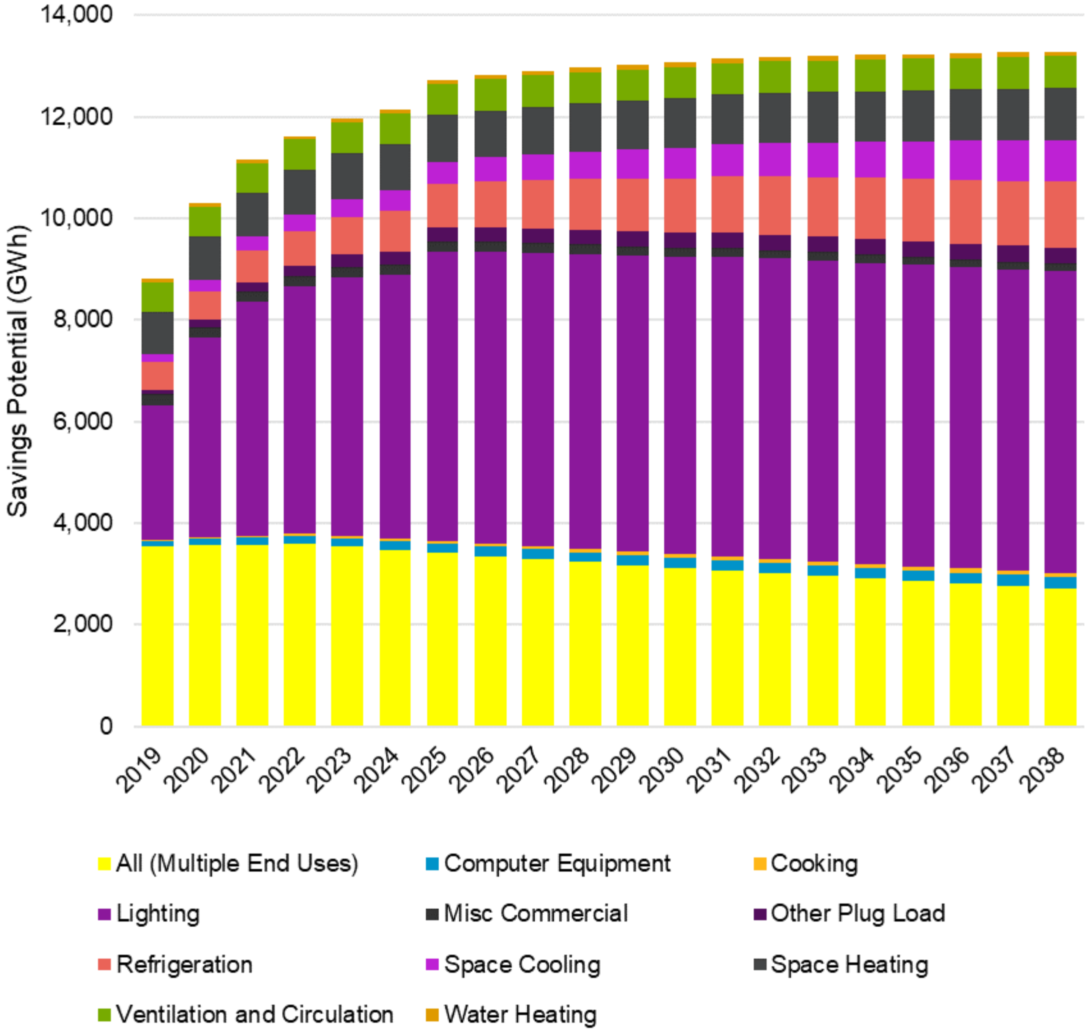
[53] Recall that all potential estimated by this potential study is intended to be potential over and above the effects of natural conservation embedded in the reference forecast—i.e., net of free riders.

[54] Note that in this case the denominator for the All (Multiple End Uses) end use is total sectoral consumption.

Notable exceptions are the other plug load and miscellaneous residential end uses. In the case of the miscellaneous residential end use this is due to forecast growth in consumption outstripping the growth in potential: the reference forecast predicts an increase in miscellaneous residential loads of 35% between 2018 and 2028.

Figure 6-8 shows the electric energy economic potential across all commercial end uses.

Figure 6-8. Commercial Electric Energy Economic Potential by End Use (GWh)



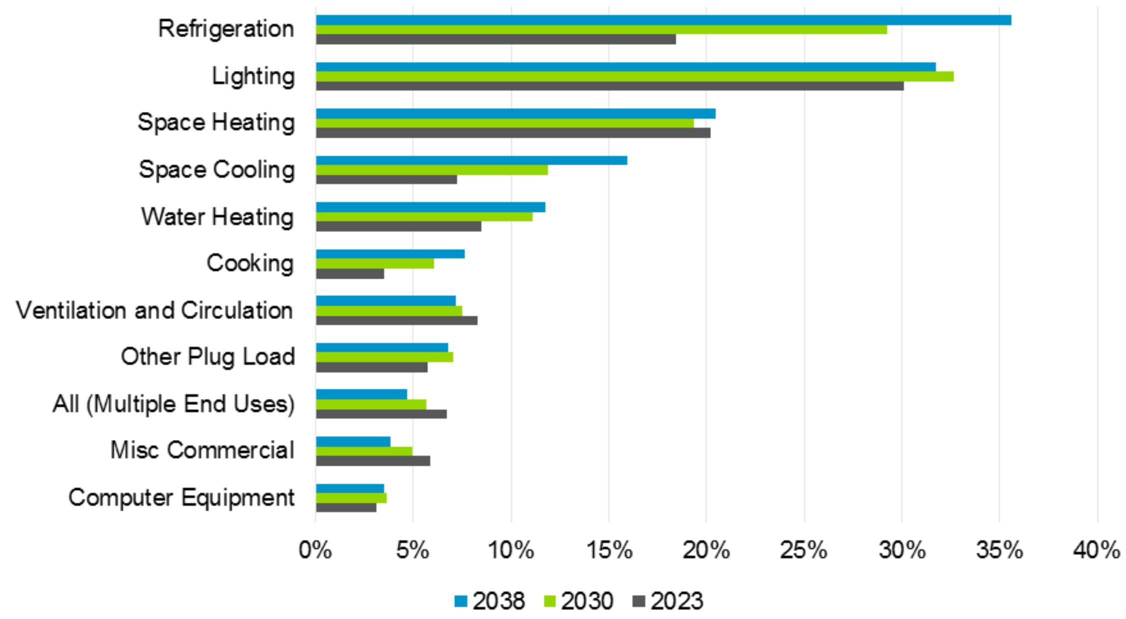
Source: Navigant analysis

Similar to the technical potential, the major opportunity for electricity savings economic potential in the commercial sector exists in the lighting end use, while at the same time lighting is the end use that exhibits the greatest decrease in potential from the technical potential. This is primarily due to the central lighting control system measure (number one measure for commercial electric energy technical potential) not being cost-effective.

The observed decline in the multiple end uses end use potential is a function of building stock turnover, and the fact that it is RET measures that dominate the potential for the commercial sector's end use (e.g., building recommissioning). As building stock turns over, potential associated with the additional insulation installed in older buildings (for example) decreases.

Figure 6-9 shows commercial electric energy savings potential by end use as a percentage of end use consumption for three years of the forecast: 2023, 2030, and 2038.

Figure 6-9. Commercial Electric Energy Economic Potential by End Use as a Percentage of End Use Forecast Consumption

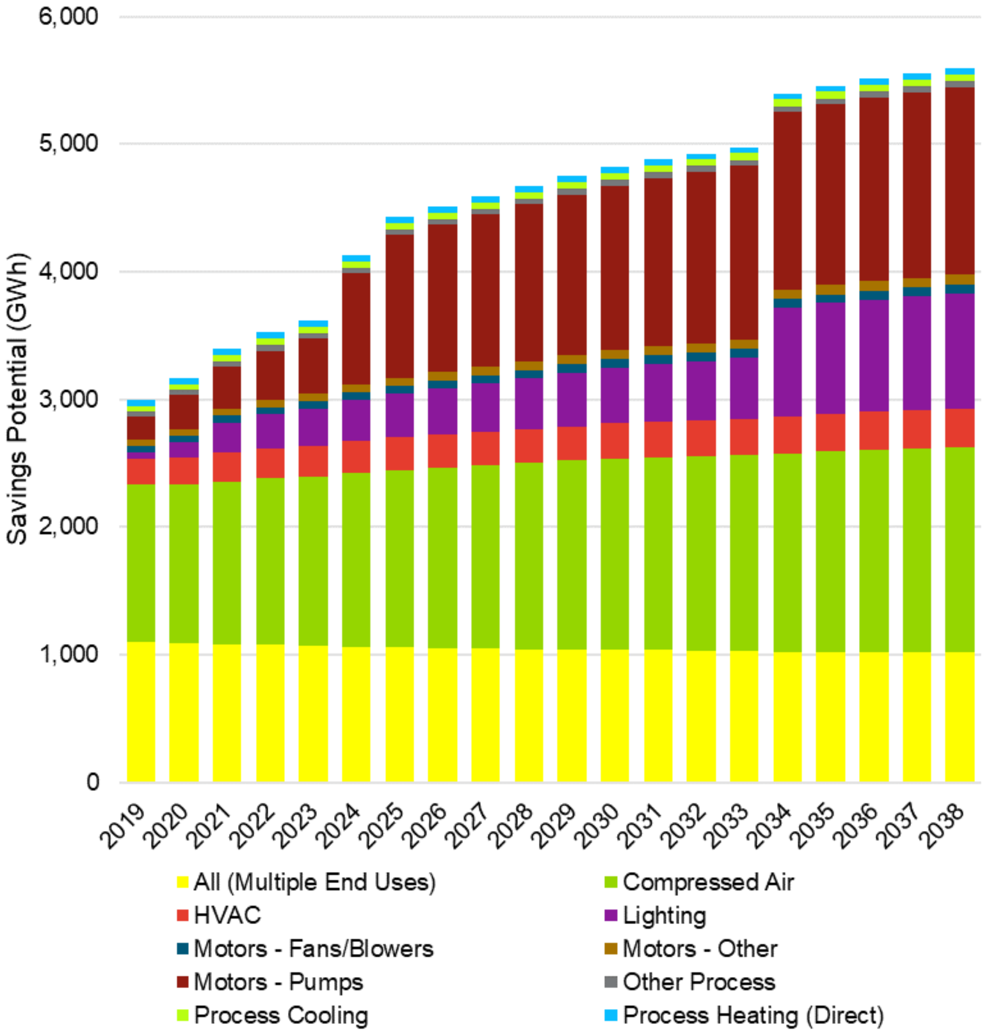


Source: Navigant analysis

For the most part, the trends follow those seen with technical potential with a few notable drops. When looking at 2038, the end uses with the greatest reduction in absolute percentage decrease from technical potential to economic potential were the refrigeration with an approximately 20% decrease, and space heating and other plug load end uses which both had approximately 15% decreases.

Figure 6-10 shows the electric energy economic potential across all industrial end uses.

Figure 6-10. Industrial Electric Energy Economic Potential by End Use (GWh)

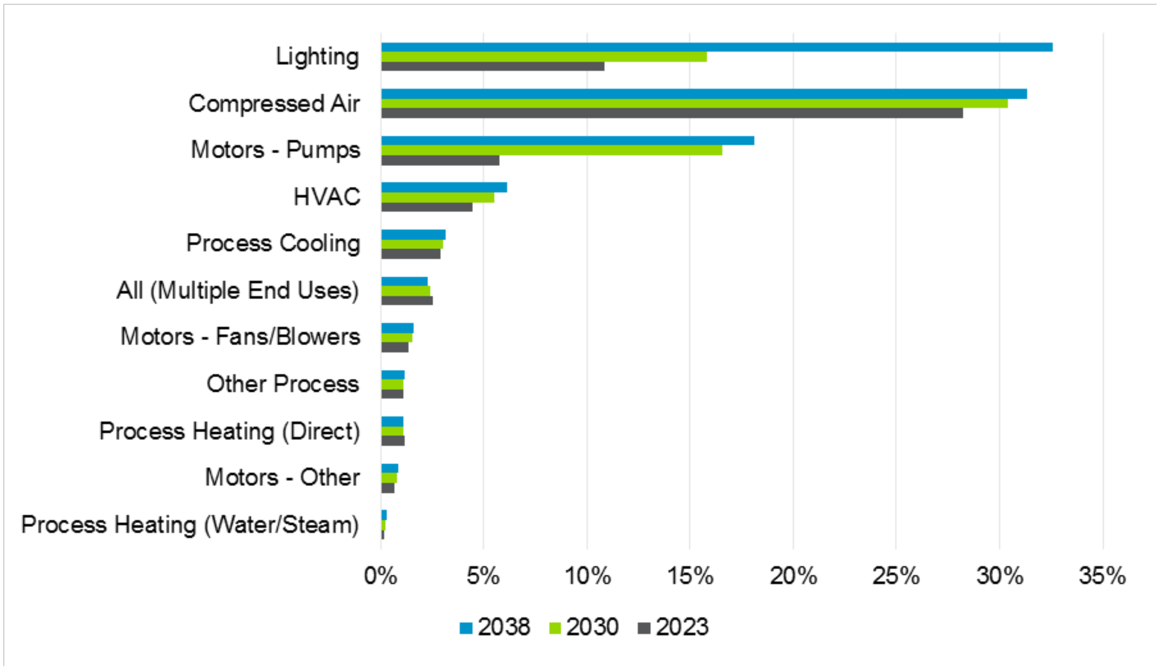


Source: Navigant analysis

The average rate of economic potential growth by end use over the potential reference forecast period is similar to the average rate of technical potential growth with two notable exceptions. Both the motors – pumps and lighting end uses have lower economic potential due to key measures not becoming cost-effective until in 2024 when the motors – pumps measures become cost-effective and in 2034 when the lighting measures become cost-effective.

Figure 6-11 shows industrial electric energy savings potential by end use as a percentage of the consumption for three years of the forecast, 2023, 2030, and 2038.

Figure 6-11. Industrial Electric Energy Economic Potential by End Use as a Percentage of End Use Forecast Consumption

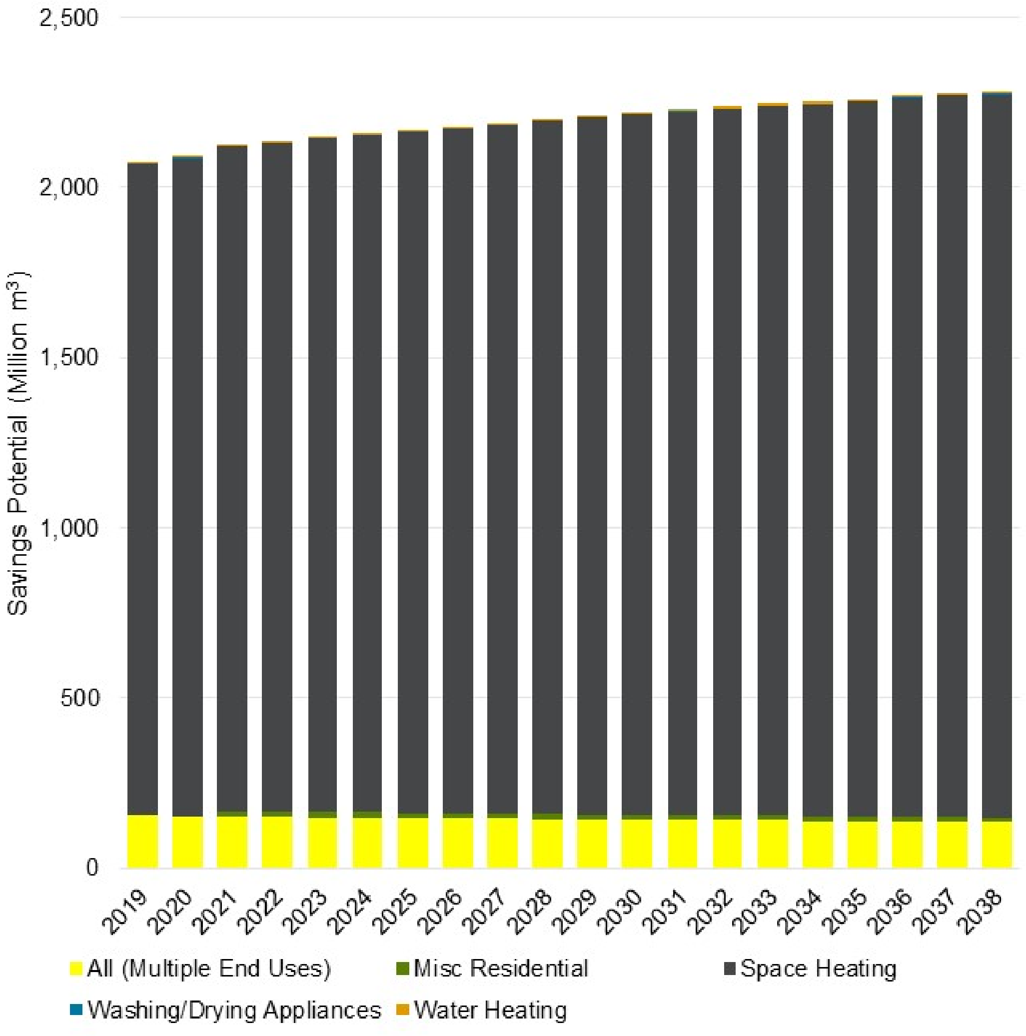


Source: Navigant analysis

For the most part, the trends follow those seen with technical potential with minimal differences between technical and economic potential in 2038. This is mainly due to the data source for industrial measures including measures that were pre-screened to be those likely to be cost-effective.

Figure 6-12 shows the natural gas economic potential across all residential end uses.

Figure 6-12. Residential Natural Gas Economic Potential by End Use (Million m^3)

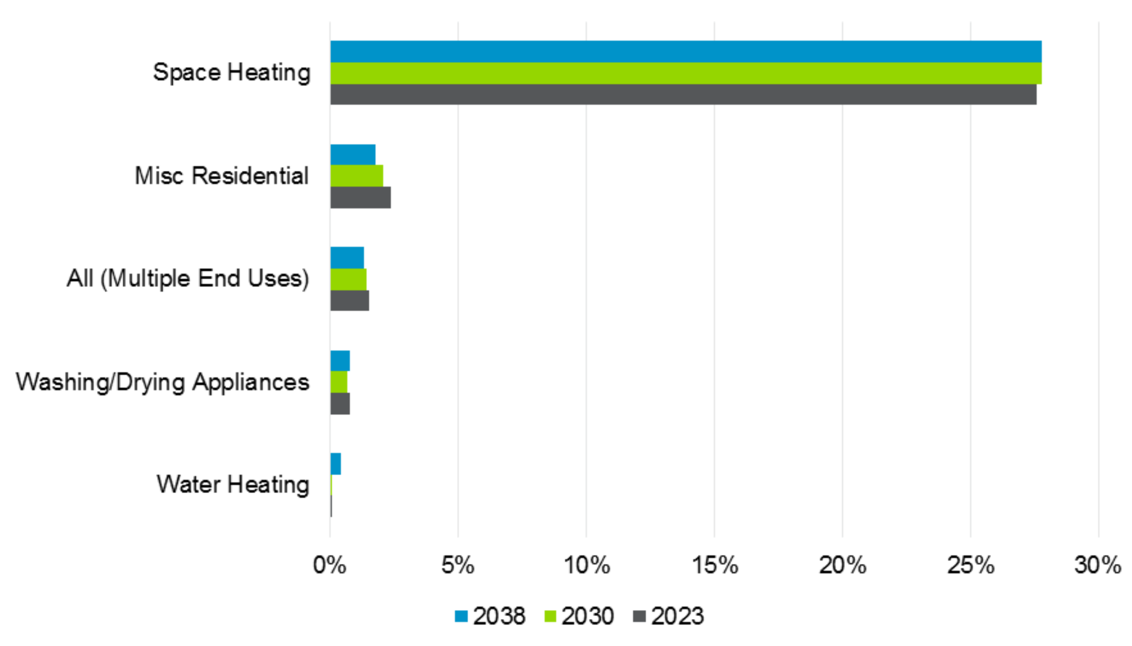


Source: Navigant analysis

Similar to technical potential, given the fuel, the vast majority of economic potential exists in the space heating end use. The main difference exhibited as compared to the technical potential is that there is significantly less economic water heating potential. This is because the water heating measures are not cost-effective in the majority of customer segments and service territories.

Figure 6-13 shows residential natural gas energy savings potential by end use as a percentage of that end use's consumption for three years of the forecast, 2023, 2030, and 2038.

Figure 6-13. Residential Natural Gas Energy Economic Potential by End Use as a Percentage of End Use Forecast Consumption

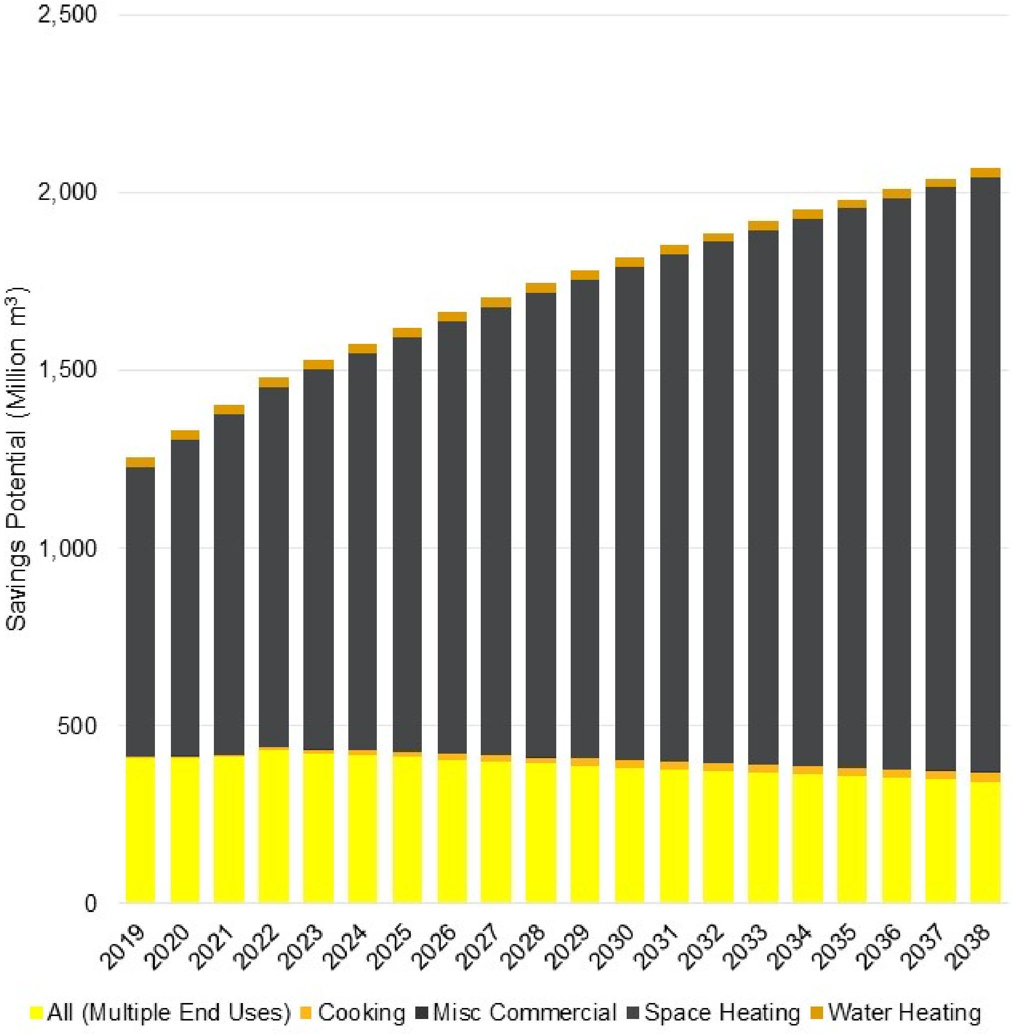


Source: Navigant analysis

For the most part, the trends follow those seen with technical potential with a few notable drops. The end uses with the greatest reduction in savings in 2038 from technical potential to economic potential were water heating dropping to almost 0%, and space heating with an approximately 10% decrease.

Figure 6-14 shows the natural gas economic potential across all commercial end uses.

Figure 6-14. Commercial Natural Gas Economic Potential by End Use (Million m^3)

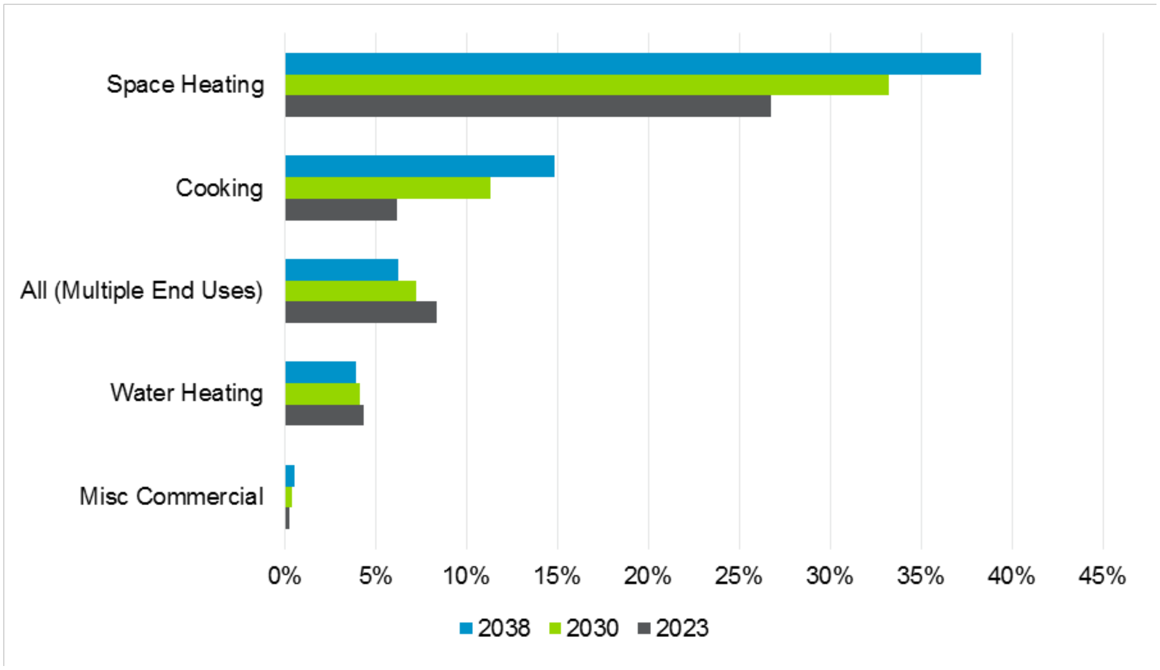


Source: Navigant analysis

Similar to technical potential, the vast majority of savings potential in the commercial sector is derived from the space heating end use. In addition, nearly all of the technical potential was cost-effective, with slight reductions in the All (multiple end uses) and space heating end uses' potentials accounting for the difference.

Figure 6-15 shows commercial natural gas economic potential by end use as a percentage of end use consumption for three years of the forecast, 2023, 2030, and 2038.

Figure 6-15. Commercial Natural Gas Energy Economic Potential by End Use as a Percentage of End Use Forecast Consumption

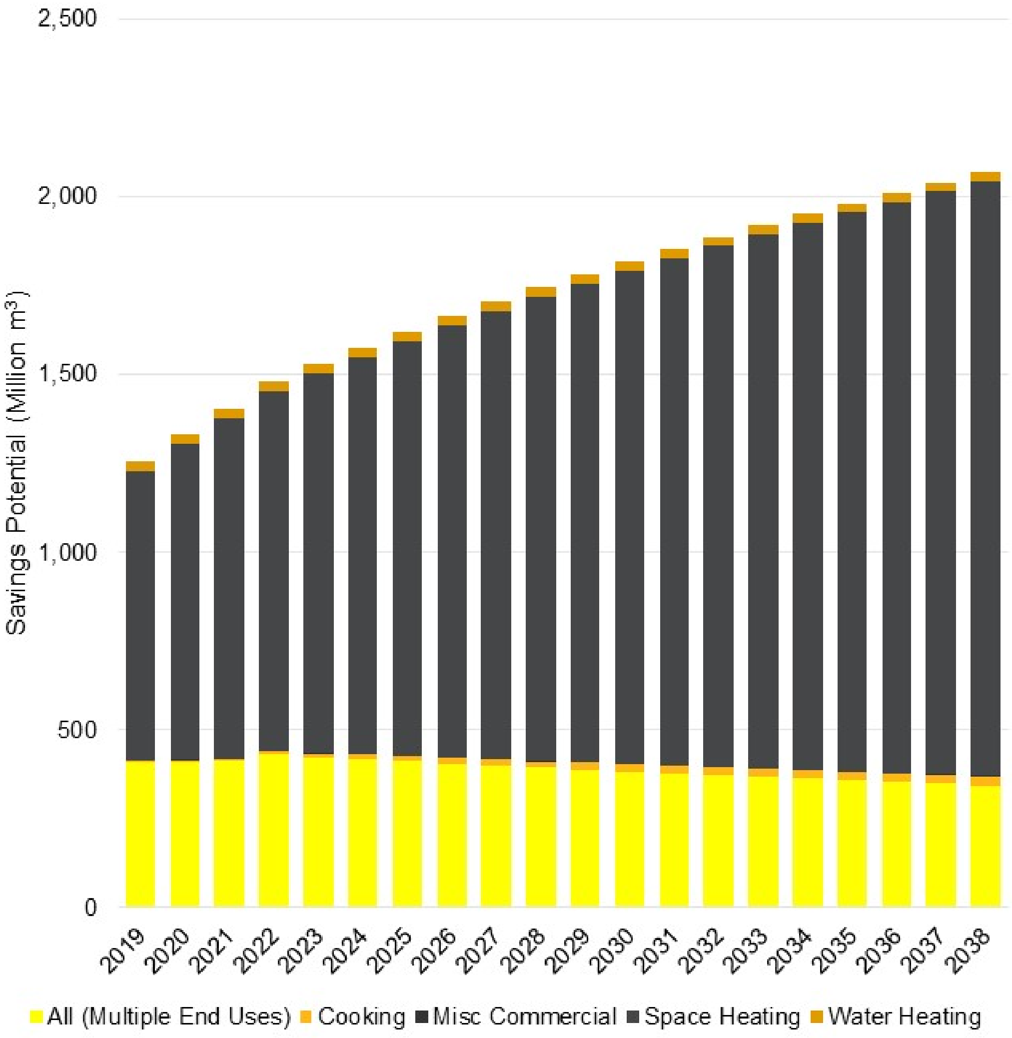


Source: Navigant analysis

For the most part, the trends follow those seen with technical potential with only a few minor decreases seen in the space heating, water heating, and misc. commercial end uses.

Figure 6-16 shows the natural gas economic potential across all industrial end uses.

Figure 6-16. Industrial Natural Gas Economic Potential by End Use (Million m^3)

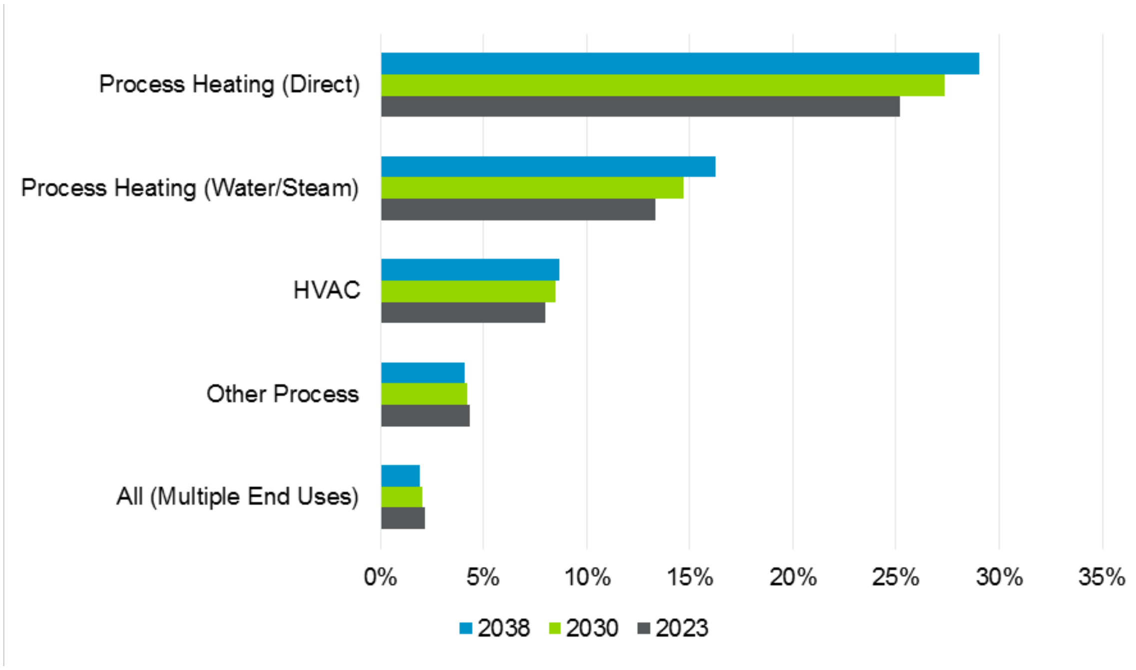


Source: Navigant analysis

Similar to technical potential, the vast majority of savings potential in the industrial sector is derived from the process heating (direct) end use. In addition, nearly all of the technical potential was cost-effective, with slight reductions in the process heating (water/steam) end use's potentials accounting for the difference.

Figure 6-17 shows industrial natural gas economic potential by end use as a percentage of end use consumption for three years of the forecast, 2023, 2030, and 2038.

Figure 6-17. Industrial Natural Gas Energy Economic Potential by End Use as a Percentage of End Use Forecast Consumption



Source: Navigant analysis

For the most part, the trends follow those seen with technical potential with only a few minor decreases seen in the process heating (water/steam) industrial end use.

6.3.3 Results by Measure

The measure-level savings potential shown in the following tables includes adjustments made to competition groups. In other words, these tables provide only measures that “won” their respective competition groups. For example, the residential electric measure table lists smart burners (a cooking measure), but not induction cooking stove tops, a competing measure that saves less electricity than the smart burners and, therefore, “loses” when the competition groups are considered. For economic potential, a measure winning its competition group indicates that it was cost-effective and of the cost-effective measures in the competition group, it had the greatest energy savings.

Note also that these measure-level potential values have not been adjusted for measure stacking, as that step occurs as part of potential aggregation. Note that in the achievable scenarios, the measure stacking adjustment tends to be quite small—for example in Scenario A, the residential summary potential in 2038 (which accounts for stacking) is 0.13% less than the unstacked measure-level potential.

In addition to providing the annual potential energy savings associated with the cumulative adoption of each measure across the period of projection, each table also provides the proportion of total sectoral potential for which that measure accounts, in the given year.

In reviewing the residential measures in Table 6-3, it should be noted that the residential sector includes multifamily buildings, including whole building measures (such as building recommissioning).

Table 6-3 presents the top 20 residential electricity measures in 2038 ranked by economic potential. Three of the top five measures seen in technical potential remain in the top five in economic potential. The two measures that dropped out of the top five technical potential were ENERGY STAR refrigerators and smart burners. An additional nuance of these results is the effect on a measure's contribution to economic of the granular fashion in which cost-effectiveness is assessed. For example, smart burners are one of the top five measures contributing to technical potential, but ranked only number 12 in economic potential. This is a result of the cost-effectiveness of these measures changing over time. Smart power bar retained its top spot and ranks as the highest impact economic potential measure. Note that smart power bars only pass the cost-effectiveness test in 2038, but capture the top spot due to the fact that it is a retrofit measure and therefore – in the economic potential – assumed to be adopted as soon as it becomes cost-effective (this is in contrast to – for example –smart burners which are adopted as stock of the base equipment turns over).

Table 6-3. Top 20 Measures for Residential Electric Measure-Level Economic Potential in 2038

Measure Rank	Measure Name	Potential (GWh)	% of Pot.
1	Smart Power Bar	1,202	12%
2	ENERGY STAR LED Bulbs General Purpose LEDs	1,176	11%
3	ENERGY STAR A Line, PAR, MR Lamps	1,026	10%
4	Ductless Mini-Split Heat Pump	804	8%
5	ENERGY STAR Clothes Washer	801	8%
6	Adaptive Thermostat	700	7%
7	ENERGY STAR Air Source Heat Pump	458	4%
8	Air Sealing	432	4%
9	Car Block Heater Timer	371	4%
10	ENERGY STAR Torchiere	326	3%
11	Variable Speed Pool Pump Motor	317	3%
12	Smart Burners	285	3%
13	ENERGY STAR Clothes Dryer	261	3%
14	Building Recommissioning, Operations and Maintenance (O&M) Improvements	246	2%
15	Basement Wall Insulation	227	2%
16	Attic Insulation	175	2%
17	ENERGY STAR Room Air Conditioner	142	1%
18	ENERGY STAR Light Fixture	140	1%
19	Comprehensive Draft Proofing	125	1%
20	LED Parking Lot Fixture	81	1%

Source: Navigant analysis

Table 6-4 presents the top 20 commercial electricity measures in 2038 ranked by economic potential. Four of the top five technical potential measures seen in technical potential remain in the top five in economic potential, as most of the measures were very cost-effective lighting measures. The measure that dropped out of the top five was the central lighting control system. Building recommissioning, operations and maintenance improvements replaced the central lighting control system at the top spot as the highest impact economic potential measure.

Table 6-4. Top 20 Measures for Commercial Electric Measure-Level Economic Potential in 2038

Measure Rank	Measure Name	Potential (GWh)	% of Pot.
1	Building Recommissioning, Operations and Maintenance (O&M) Improvements	1,732	13%
2	LED Low/High Bay	1,062	8%
3	ENERGY STAR LED LAMPS (REFLECTOR LAMPs/MR16/PAR 16)	959	7%
4	LED Troffer/Surface/Suspended	865	6%
5	LED Replacement Lamp (Tube)	830	6%
6	High Efficiency Air Source Heat Pump	780	6%
7	LED EXTERIOR AREA LIGHTS - LED fixture (200W)	669	5%
8	Education and Capacity Building/Energy Behavior	651	5%
9	LED parking lot fixture	634	5%
10	Furnace Tune-Up	476	4%
11	LED street light fixture	409	3%
12	Refrigerated Display Case Doors	408	3%
13	Reach-in Shaded Pole to ECM/PSC Evaporator Fan Motor	388	3%
14	Demand Control Ventilation	340	3%
15	Advanced BAS/Controllers	340	3%
16	Data Centre Storage/Server Virtualisation	311	2%
17	Strip Curtains	258	2%
18	Unitary Air-Conditioning Unit	231	2%
19	Centrally controlled desktop PC/NETWORK PC POWER MANAGEMENT SOFTWARE	213	2%
20	LED or Equivalent Sign Lighting	183	1%

Source: Navigant analysis

Table 6-5 presents the top 20 industrial electricity measures in 2038 ranked by economic potential. All of the top five measures seen in technical potential remain in the top five in economic potential. Pump system optimisation retained the top spot and ranks as the highest impact economic potential measure.

Table 6-5. Top 20 Measures for Industrial Electric Measure-Level Economic Potential in 2038

Measure Rank	Measure Name	Potential (GWh)	% of Pot.
1	Pump System Optimisation	911	16%
2	HE Lighting	728	13%
3	Air Leak Survey and Repair	612	11%
4	Air Compressor Optimisation	504	9%
5	Efficient Compressed Air Nozzles	487	9%
6	Recommissioning	424	8%
7	SEM (Strategic Energy Management)	424	8%

Measure Rank	Measure Name	Potential (GWh)	% of Pot.
8	Pump Equipment Upgrade	413	7%
9	High Efficiency HVAC Fans	262	5%
10	Greenhouse Grow Lights	174	3%
11	Process Optimisation (Elec)	171	3%
12	Material Handling Improvements	78	1%
13	Fan System Optimisation	69	1%
14	Pulp and Paper Process Improvements	65	1%
15	Refiner Plate Improvements	60	1%
16	Process Heat Recovery	37	1%
17	High Efficiency Battery Charger	25	0%
18	VAV Conversion Project	23	0%
19	Improved Controls - Process Cooling	20	0%
20	Efficient Irrigation	20	0%

Source: Navigant analysis

Table 6-6 presents the top 20 residential natural gas measures in 2038 ranked by economic potential. Only two of the top five measures seen in technical potential remain in the top five in economic potential. The measures that dropped out of the top five were the condensing storage water heater, energy star windows, and tankless water heater measures. Air sealing retained the top spot and ranks as the highest impact economic potential measure.

Table 6-6. Top 20 Measures for Residential Natural Gas Measure-Level Economic Potential in 2038

Measure Rank	Measure Name	Potential (Mm^3)	% of Pot.
1	Air Sealing	505	21%
2	Adaptive Thermostat	498	21%
3	Heat Recovery Ventilator	161	7%
4	Comprehensive Draft Proofing	152	6%
5	High Efficiency Fireplace with Pilotless Ignition	143	6%
6	High Efficiency Condensing Furnace	134	6%
7	Attic Insulation	123	5%
8	Condensing Boiler	115	5%
9	Basement Wall Insulation	103	4%
10	Condensing Make Up Air Unit	99	4%
11	Advanced BAS/Controllers	63	3%
12	Building Recommissioning, Operations and Maintenance (O&M) Improvements	52	2%
13	Floor Insulation	40	2%
14	Duct Insulation	38	2%
15	Duct Insulation MF	37	2%
16	Demand Control Ventilation	28	1%
17	Home Energy Reports	20	1%
18	Pool Cover	13	1%

Measure Rank	Measure Name	Potential (Mm^3)	% of Pot.
19	Wall Insulation	12	1%
20	Wall Insulation MF	6	0%

Source: Navigant analysis

Table 6-7 presents the top 20 commercial natural gas measures in 2038 ranked by economic potential. All of the top five measures seen in technical potential remain in the top five in economic potential, and the condensing boiler retained the top spot and ranks as the highest impact economic potential measure.

Table 6-7. Top 20 Measures for Commercial Natural Gas Measure-Level Economic Potential in 2038

Measure Rank	Measure Name	Potential (Mm^3)	% of Pot.
1	Condensing Boiler | Std	359	17%
2	Gas Fired Rooftop Units	242	11%
3	Demand Control Ventilation	216	10%
4	Building Recommissioning, Operations and Maintenance (O&M) Improvements	200	9%
5	Boilers - Advanced Controls (Steam Systems)	152	7%
6	Adaptive Thermostats	135	6%
7	Condensing Make Up Air Unit	123	6%
8	Gas Fired Heat Pump	101	5%
9	Advanced BAS/Controllers	78	4%
10	Demand Control Kitchen Ventilation	76	4%
11	Air Handler with Dedicated Outdoor Air Systems	75	4%
12	Condensing Unit Heaters or other Efficient Unit Heating System	72	3%
13	Education and Capacity Building/Energy Behavior	63	3%
14	Steam System Optimisation	40	2%
15	Destratification	38	2%
16	Furnace Tune-Up	38	2%
17	Wall Insulation	21	1%
18	Energy Efficient Laboratory Fume Hood	15	1%
19	Demand controlled Circulating Systems	11	1%
20	Infrared Heaters	11	0%

Source: Navigant analysis

Table 6-8 presents the top 20 industrial natural gas measures in 2038 ranked by economic potential. All of the top five measures seen in technical potential remain in the top five in economic potential, and process heat improvements retained the top spot and ranks as the highest impact economic potential measure.

Table 6-8. Top 20 Measures for Industrial Natural Gas Measure-Level Economic Potential in 2038

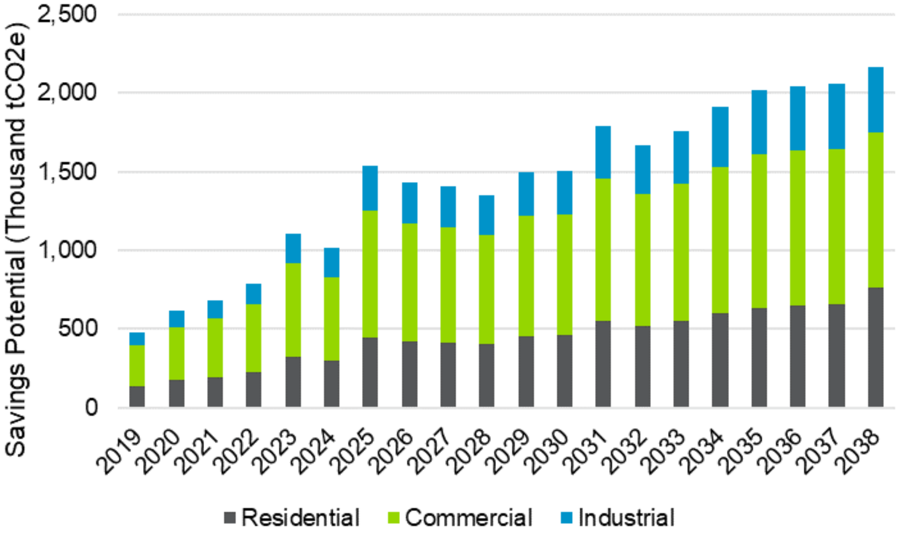
Measure Rank	Measure Name	Potential (Mm^3)	% of Pot.
1	Process Heat Improvements	905	37%
2	Boiler Upgrade	350	14%
3	Process Heat Recovery (Gas)	303	12%
4	Recommissioning	218	9%
5	High Efficiency Burners	171	7%
6	Improved Controls -Process Heating Gas	139	6%
7	Greenhouse Envelope Improvements	95	4%
8	High Efficiency HVAC Fans (Gas)	43	2%
9	Insulation - Steam	42	2%
10	VAV Conversion Project (Gas)	35	1%
11	Direct Contact Water Heaters	31	1%
12	HE HVAC Controls	24	1%
13	Steam Trap Repair	20	1%
14	Insulation - Steam (AG)	18	1%
15	Air Compressor Heat Recovery	15	1%
16	High Efficiency Furnaces	13	1%
17	Steam Turbine Optimisation	10	0%
18	HE Stock Tank	9	0%
19	Process Optimisation (Gas)	9	0%
20	Gas Turbine Optimisation	7	0%

Source: Navigant analysis

6.3.4 Emissions Reductions Results

Figure 6-18 shows the total electric energy economic emissions reduction potential for each sector. The general trend can be found to track the potential of each sector and the trend seen with economic potential, with the drops in 2024, between 2025 and 2028, and in 2032 being due to the forecast decline in the emissions intensity (as seen in Figure 5-23 of the technical potential chapter) of electricity being greater than the growth of potential in those years.

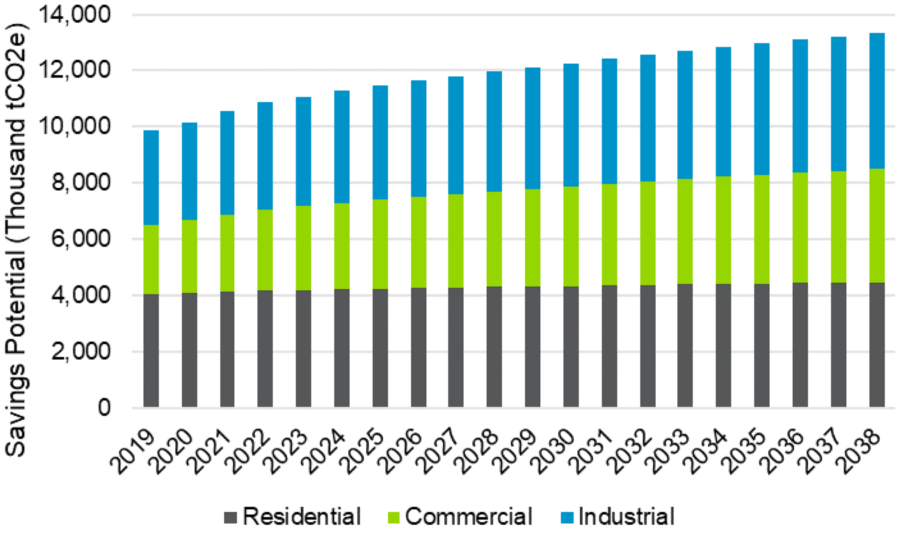
Figure 6-18. Electric Energy Economic Emissions Reduction Potential by Sector (Thousand tCO2e)



Source: Navigant analysis

Figure 6-19 shows the total natural gas energy economic emissions savings potential for each sector. Given that a constant GHG emissions intensity was assumed for natural gas, the trend of abated emissions directly tracks the economic potential over time as well as the trend seen with the technical potential.

Figure 6-19. Natural Gas Energy Economic Emissions Savings Potential by Sector (Thousand tCO2e)



Source: Navigant analysis

7. ACHIEVABLE POTENTIAL FORECAST

This chapter outlines the approach used to estimate achievable savings potential and summarise the results of that estimation, Achievable potential is the energy efficiency potential that is both cost-effective and likely to be adopted given expected customer responses to assumed incentive levels and other non-financial factors that affect customer decision making. The section begins by explaining Navigant's approach to estimating achievable potential. It then presents the results for achievable potential.

The objective of the achievable potential task is to provide an estimate of the economically feasible achievable energy conservation potential in Ontario across the 20-year potential reference forecast period covered by the potential study under four different scenarios. Achievable potential is a subset of economic potential and provides a value of the projected potential from future conservation efforts constrained by realistic consumer measure adoption levels associated with different incentive levels. Consumer measure adoption is modelled as a function of two factors: payback acceptance (what is the maximum possible market share of a measure, given the measure's simple payback), and consumer awareness which adjusts the maximum possible market share to reflect the effects of market barriers (ability to acquire a measure), marketing and the network effects of word-of-mouth. The two key levers applied to generate different achievable scenarios are: measure incentives (which reduce a measure payback), and adoption parameters (e.g., awareness through the effect of marketing) that can be adjusted to reflect assumed success of the non-financial components of program design.

The achievable potential outputs from Navigant's model are driven by the inputs from the economic potential task (specifically, which measures are cost-effective in which years, segments, and zones), and the outcomes of a Delphi Panel consultation, the focus of which was developing Ontario-specific adjustments to Navigant's existing adoption parameters and payback acceptance curves.

The estimated achievable potential, and the associated estimated program costs, are the core outputs of this potential study.

This chapter of the report is divided into three sections:

1. **Scope:** Defines the key outputs generated as part of the achievable potential analysis.
2. **Methodology:** Provides a high level description of the key assumptions and analytic approaches used to estimate the achievable potential. Additional detail on select methods may be found in Appendix F.
3. **Results**: Provides a summary of the results of the achievable potential estimation.

7.1 Scope

When calculating achievable potential, Navigant estimated savings potential for the cost-effective measures including annual electric energy, electric summer peak demand, and natural gas savings as well as the associated carbon savings and program cost estimates for 2019-2038. Achievable potential is estimated by zone, sector, segment, and end use. In addition to the considerations introduced in the economic potential section, the estimation of achievable potential addresses the following considerations (see the Methodology section for more details). These have classified into four categories:

- **Characterising Customer Behaviour**:
    - **Payback Acceptance (Willingness to Adopt).** Consumers make decisions based on the economic attractiveness of a measure, specifically, the time required to recover the cost of the investment through saving energy (i.e., payback period). Customer perception

of non-energy impacts (NEIs) such as comfort and productivity are also considered as part of this set of model inputs as they affect a customer's interest in adopting a measure.

  - **Awareness (Ability to Adopt).** This set of model inputs encapsulates factors that drive measure adoption, which are outside of the characteristics of the technology or measure itself. This includes whether a customer is aware of a measure and its merits, which can be driven by marketing as well as word-of-mouth. Market barriers also impact the ability of consumer to adopt the measure and can be driven by factors such as experience of local program staffers with similar measures, stocking of measures on shelves, and ability of supply chains to support consistent resupply of measures to retailers.

- **Setting Incentives and Scenarios**
  - **Incentive Approaches.** The manner in which incentives are applied can have a significant effect on estimated adoption. Across the four scenarios modelled, the incentive levels range from more constrained to covering the full incremental measure cost.
  - **Scenarios.** Navigant has estimated four sets of achievable potential results, corresponding to different scenarios of incentive spending, total program cost, targeted savings level, and assumed quality of program design. Three of the four scenarios consider all measures. One of these three scenarios is the maximum achievable scenario that assumes incentives completely defray all incremental measure costs, and an ideal program design (see the Maximum Achievable Scenario under the Scenarios section for more details.). Two of these three apply constraints to incentive spending, total program cost, or targeted savings level, and do not assume an ideal program design. A fourth scenario applies incentives to measures that impact summer peak demand.
- **Modelling Measure Interactions**
  - **Competition Groups.** Cases in which two or more mutually exclusive measures exist (e.g., storage water heaters and tankless water heaters). For technical potential the measure with the highest savings is assumed to be adopted. For economic potential, the measure with the highest savings that is also cost-effective is assumed to be adopted. For achievable potential, measures are adopted based on the economic attractiveness to consumers, after considering the impact on measure incremental cost of incentives.
  - **Measure Stacking.** When two measures that share the same end use are installed at the same time, the total savings of the two combined may be less than the sum of their individual savings. As with technical and economic potential, Navigant explicitly controls for the diminishing marginal savings associated with the combined adoption of measures within the same end use.
- **Calculating Program Costs**:
  - **Administrative Cost Approaches.** The costs to administer programs (and deliver estimated achievable potential) include both the cost of paying incentives, and the non-incentive cost (overheads, personnel, marketing, etc.) of delivering programs. These non-incentive costs, described in this study as administrative costs, were included in the program cost calculations described in this chapter.
  - **Net Savings Study.** As has been noted elsewhere in this potential study, since the effects of natural conservation are accounted for in the reference forecasts, all estimated potential values are net of free riders. It is important to note, however, that in any actual program implementation there are usually free riders (consumers acquiring savings without being influenced by programs are excluded from the achievable potential scenarios), and that the estimated incentive and administrative costs presented below make no adjustment for this – they are the costs associated with achieving the net potential, not the costs of free riders participating in programs.

The key outputs of this analysis are:

- **Electric energy achievable savings potential (GWh)** from energy conservation measures.
- **Natural gas achievable savings potential (millions of m^3)** from energy conservation measures.
- **Electric summer peak demand achievable savings potential (MW)** from energy conservation measures.
- **GHG emissions reductions (Mt CO2e)** associated with the achievable potential values cited above.
- **Program costs**; the annual incentive and administrative costs associated with the estimated achievable potential.
- **Cost curves** showing the achievable potential savings and associated program costs between zero potential and the maximum level of achievable potential for three specified years for electric energy and natural gas.

In addition to generating the achievable potential results, additional deliverables included discussing the results with the Project Team and Advisory Group for feedback, and summarising the methodology, data sources and results in the final report.

7.2 Methodology

This section summarises Navigant's approach to estimating achievable potential.

The critical first step in the process of reasonably estimating achievable potential is to simulate market adoption of energy efficiency measures. The approach to simulating the adoption of energy efficient technologies for purposes of estimating achievable potential can be broken down into the following two steps:

- Estimation of the ultimate market share
- Calculation of the dynamic growth of adoption toward the ultimate equilibrium market share

A measure's ultimate market share is determined through adoption rates driven by the customer's ability and willingness to adopt, as defined above. The calculation of the customer's willingness to adopt takes as inputs the incentives assumed (and how those incentives reduce a measure's payback) for different achievable potential scenarios. The estimated adoption under the various scenarios drives the program incentive and administrative cost estimates, and, as for economic and technical potential, adoption and associated potential savings are modified by the effects of measure competition and stacking.

7.2.1 Characterizing Customer Behaviour

7.2.1.1 Payback Acceptance (Willingness to Adopt)

The percentage of the market willing to adopt (i.e., the market share) can be thought of as the percentage of individuals choosing to purchase a measure, provided those individuals are fully aware of the technology and its relative merits (e.g., the energy- and cost-savings features and non-energy impacts). For energy efficiency technologies, a key differentiating factor between the baseline and the energy efficiency measure is the energy and cost savings associated with the energy efficiency measure. Additional efficiency compared to the baseline often comes at a premium in initial cost (i.e., the incremental measure cost). Thus, in efficiency potential studies, the percentage of the market willing to adopt (the market share) is typically calculated as a function of the payback time of the energy efficiency measure relative to the baseline measure. This theoretical construct is often referred to as payback acceptance: for a given measure payback, X% of consumers will be willing to adopt this measure. This relationship between payback and market share is characterised as a payback acceptance curve.

Navigant uses payback acceptance curves developed using primary research conducted in Ontario based on the Delphi method[55] in 2019. To develop these curves, Navigant conducted surveys and held discussions with a group of experts representing both consumers and utilities from the commercial, residential, and industrial sectors. In lieu of being able to survey hundreds of customers from each sector, each group of experts with in-depth knowledge of each sector, each called a Delphi Panel, was brought together to share their expertise regarding consumer habits and market trends as the next-best approximation of comprehensive consumer surveys. The surveys given to each Delphi Panel presented the experts with technologies with both low and high upfront costs and varying annual energy savings and requested their input. Following the completion of the survey, a series of virtual discussions with panelists were held to review and solicit feedback on the findings of the survey. Acknowledging that different customer groups respond differently to financial and non-financial drivers, customers were broken down into the following groups for the purposes of the Delphi panel:

Customer Groupings

- Residential: Low income households
- Residential: Non-low income households
- Commercial: Business facilities (e.g., offices, hotels, department stores, etc.)
- Commercial: Institutional facilities (e.g., hospitals, schools, etc.)
- Industrial: Agriculture
- Industrial: Resource extraction, refining, and manufacturing
- Industrial: Consumer goods manufacturing

Navigant used the Delphi Panel survey responses and virtual discussion feedback to estimate a set of exponential equations to deliver the set of payback acceptance curves used in the achievable potential analysis. These curves are illustrated in Appendix F.2.

In addition to the payback acceptance curves, the Delphi Panel provided guidance regarding how non-energy impacts (NEI) influence customers' willingness to adopt a measure, and hence that measure's market share. Specifically, each Panel was provided with a list of measures representative of different end uses within each sector. For each measure, the Delphi Panel indicated which non-energy impacts were relevant and the degree to which these impacts increased or decreased the customers' likelihood to adopt the measure. These inputs were used in conjunction with the payback periods to produce equilibrium market share values for each measure.

Because the payback time of a measure can change over time as measure costs and/or energy costs change, the equilibrium market share (the percentage of consumers that are aware of and able to adopt that will ultimately adopt that technology) can also change over time. The equilibrium market share is recalculated for every year within the market simulation to ensure the dynamics of technology adoption considers changing market share.

---

[55] A "Delphi" approach to deriving estimated values is a qualitative forecasting approach that relies on attaining a consensus of expert opinion through questionnaires, debate, and discussion.

Navigant calculated each measure’s payback period to assess a customer’s willingness to adopt the measure. The payback period is then applied to the relevant payback acceptance curve to assess the customer acceptance and adoption of the measure. The payback period is calculated after the incentive is applied to the measure cost. Equation 7-1 demonstrates the calculation.

Equation 7-1. Participant Payback Period

$$Payback = \frac{Incremental\ Measure\ Cost - Incentive}{Annual\ kWh\ Saved\ \times Annualized\ Billing\ Rate\ \left({}^{\$}/_{kWh}\right) + Annual\ Natural\ Gas\ Saved\ \times Annualized\ Billing\ Rate\ ({}^{\$}/_{m^3})}$$

Where:

- *Annual kWh Saved* and *Annual Natural Gas Saved* is calculated for each measure and segment (as appropriate).
- *Annualized Billing Rate* is the overall cost a customer pays per kWh or per m^3 consumed.
- *Incremental Measure Costs* are the costs the participant would pay (without an incentive) to implement the measure. In ROB and new construction (depending on the measure) the difference in the cost of the efficiency and standard equipment is used instead of the full cost of installation (material and labor costs).
- *Incentive* is the incentive associated with the measure for the given scenario.

7.2.1.2 Awareness (Ability to Adopt)

Payback acceptance addresses the willingness to adopt. The interim output of applying measure payback to the payback acceptance curve the equilibrium market share – the percentage of the market that is *aware of and able to adopt* would be willing to adopt the measure – was discussed in the previous section, This section addresses the approach used to estimate the proportion of consumers that are aware and able to adopt the measure.

Calculation of Awareness Growth

Navigant used two approaches to calculate the growth of awareness. The first sub-section below outlines the approach used for NEW and RET type measures (i.e., discretionary) measures, and the second outlines the approach used for technologies simulated as ROB (i.e., lost opportunity) measures.

Retrofit/New Technology Awareness Approach

RET (retrofit) and NEW (new construction) technologies employ an enhanced version of the classic Bass diffusion model.[56,57] The Bass diffusion model simulates the S-shaped awareness curve commonly observed for technology adoption, in which customer awareness of new technologies or measures grows slowly in early years, then rapidly increases as more customers become aware of and adopt the measure and finally tapers off as the market becomes fully aware and equilibrium adoption is reached.

In this model, consumer adoption and associated achievable savings potential is driven by two primary mechanisms, (1) external influences such as program marketing and advertising, and (2) internal influences including customer word-of-mouth. It also accounts for other market barriers in the market. The

---

[56] Bass, Frank (1969). “A new product growth model for consumer durables.” *Management Science* 15 (5): p215–227.

[57] See Sterman, John D. Business Dynamics: Systems Thinking and Modeling for a Complex World. Irwin McGraw-Hill. 2000. p. 332.

fraction of the population willing to adopt is estimated using the payback acceptance curves illustrated in Section 7.2.1.1.

Recognition of the positive or self-reinforcing feedback generated by the word of mouth mechanism is evidenced by increasing discussion of concepts like social marketing and the term viral, which was popularized most recently by social networking sites such as Facebook and YouTube. However, the underlying positive feedback associated with this mechanism has always been part of the Bass diffusion model of product adoption since its inception in 1969.

Navigant's implementation of the Bass diffusion model uses awareness parameters developed based on input provided by the Delphi Panel. Specifically, the panel provided responses guiding the development of the initial awareness (or ability to adopt) of many measures, the early rates of awareness growth, and how many years they believed were required to reach equilibrium market share. These responses also included information regarding the extent to which market barriers impacted the rate of awareness growth for certain measures. For example, some measures might not be fully stocked on shelves, the supply chain of delivering measures to storefronts may still under development, or customers simply may not be aware of some measures. Each of these factors impacts either the awareness of the existence and merits of a technology or the ability to obtain the measure.

ROB Technology Adoption Approach

The dynamics of awareness for ROB technologies are more complicated than for NEW/RET technologies because they require simulating the turnover of technologies that have not yet reached the end of their useful lives. To account for this, the DSMSim model tracks the stock of all technologies—both base and efficient—and explicitly calculates technology retirements (or burnouts) and additions (adoption) consistent with the lifetime of the technologies. Such an approach limits the available number of baseline measures that can be replaced in any given year to only those reaching the end of their expected useful life. This affects how quickly technologies can be replaced. A model that generates growth in the familiarity of a technology is overlaid on the stock tracking model to capture the dynamics associated with the diffusion of technology familiarity.

7.2.2 Setting Incentives and Scenarios

7.2.2.1 Incentive Approaches

A key component of any potential study is determining the appropriate level at which to set measure incentives for each scenario. Navigant's model offers several different strategies for setting incentive levels, two of which were selected for the purpose of this potential study.

- ***Levelized Unit Energy Cost (LUEC) Threshold Approach:*** In this approach, incentive levels are set such that they are capped at some $/levelized kWh saving value[58]. A maximum incentive threshold is set, and if the measure's levelized cost of savings is less than this threshold, 100% of the measure's incremental cost will be covered by the incentive. However, if the levelized cost of savings of a measure is greater than the threshold, then a maximum incentive equal to the threshold will be applied to those measures. Consider an example where the LUEC incentive cap is set at 2.5 cents per lifetime kWh:

---

[58] The consumer LUEC is calculated as the incremental cost divided by the lifetime savings. Incentives, under this structure, are also applied as a LUEC – the total incentive cost divided by lifetime savings. Unless otherwise noted, references to LUEC values in this report refer to the program (incentive) cost LUEC.

  - Measure A costs $10, delivers annual savings of 40 kWh for 5 years. The consumer LUEC (the levelized unit energy cost to the consumer) is $10/(40*5) = 5 cents per kWh
  - Measure B costs $5, delivers annual savings of 100 kWh for 5 years. The consumer LUEC is $20/(100 *5) = 1 cent per kWh
  - Measure C costs $20, delivers annual savings of 40 kWh for 20 years. The consumer LUEC is $20/(40 * 20) = 2.5 cents per kWh

  With a LUEC incentive cap of 2.5 cents per kWh:

  - Measure A receives an incentive of 2.5 cents per kWh – the cap (2.5 cents * 40 kWh * 5 years = $5), or 50% of the measure incremental cost;
  - Measure B receives an incentive of 1 cent per kWh (1 cent * 100 kWh * 5 years = $5), or 100% of the measure incremental cost; and,
  - Measure C receives an incentive of 2.5 cents per kWh – the cap (2.5 cents * 40 kWh * 20 years = $20), or 100% of the measure incremental cost.

  This approach results in higher savings at lower cost than alternative approaches to specifying incentive levels, as detailed by Welch and Richerson-Smith (2012).[59] This approach also has the benefit of maximising the net benefits achieved. A drawback of this approach is it can result in a portfolio that may be considered less comprehensive—that is, more expensive emerging technologies may receive lower incentives than under another approach—since it preferentially targets lower cost savings. This approach to incentive setting was used for achievable potential scenarios A, C, and D (see below for details).

- ***Percent of Incremental Cost Approach:*** This approach calculates the incremental cost of each measure and then provides an incentive that is a specified percentage of that incremental cost. This method, while common in the industry, tends to result in lower total savings for a given specified level of program cost than the levelized cost threshold approach. This approach was used only for Scenario B, the maximum achievable potential scenario (see below for details) where the incentive was set to cover 100% of the measure incremental cost.

The specifics of how the incentives were applied can be found in the Scenarios section, below.

7.2.2.2 Scenarios

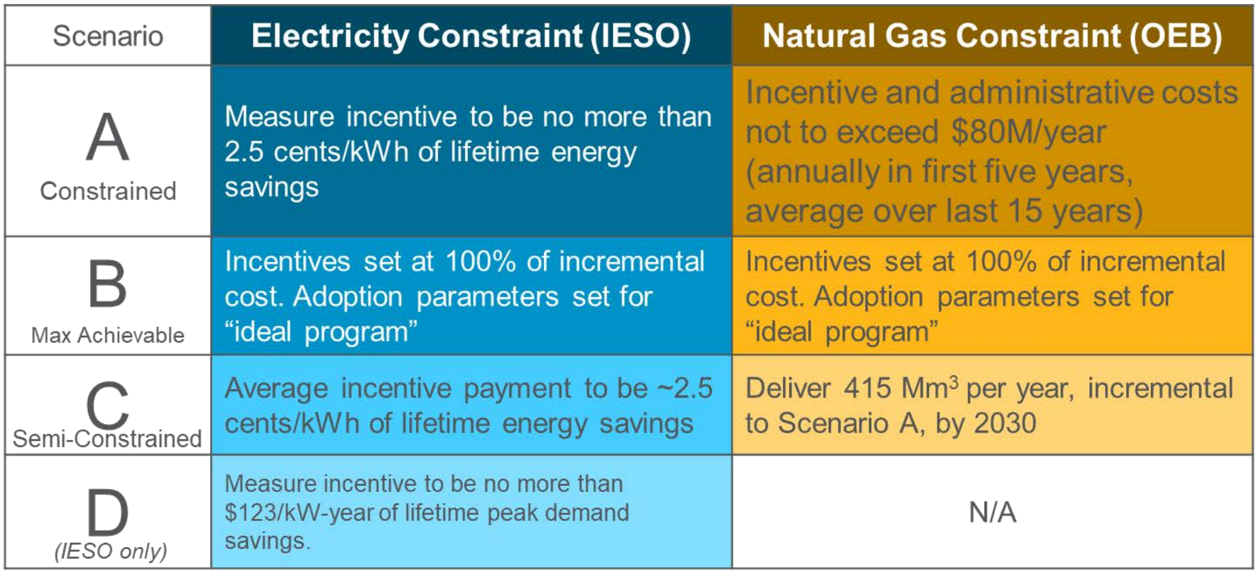
This section defines each achievable potential scenario that was modelled, including their incentives and administrative cost approaches and the reasoning behind the incentives and target constraints.

The four scenarios estimated for this potential study, and their constraints, are summarised in Figure 7-1.

---

[59] Welch, Richerson-Smith (2012). “Incentive Scenarios in Potential Studies: A Smarter Approach” Presented at the ACEEE Summer Study on Energy Efficiency in Buildings. Monterey, CA. August 2012. Available at http://www.aceee.org/files/proceedings/2012/data/papers/0193-000050.pdf.

Figure 7-1. Summary of Achievable Potential Scenarios



Scenario	Electricity Constraint (IESO)	Natural Gas Constraint (OEB)
A Constrained	Measure incentive to be no more than 2.5 cents/kWh of lifetime energy savings	Incentive and administrative costs not to exceed $80M/year (annually in first five years, average over last 15 years)
B Max Achievable	Incentives set at 100% of incremental cost. Adoption parameters set for "ideal program"	Incentives set at 100% of incremental cost. Adoption parameters set for "ideal program"
C Semi-Constrained	Average incentive payment to be ~2.5 cents/kWh of lifetime energy savings	Deliver 415 Mm^3 per year, incremental to Scenario A, by 2030
D *(IESO only)*	Measure incentive to be no more than $123/kW-year of lifetime peak demand savings.	N/A

Source: Navigant analysis

Constrained Scenario (Scenario A)

For Scenario A, electricity potential was constrained by a specific incentive cap while natural gas potential was constrained to a total program cost value approximately matching DSM program budget levels approved for 2016-2020 by the Ontario Energy Board (allowing the incentive cap to flow from that). To achieve the target program cost (mentioned in Table 7-1), it was required to vary the incentives over the reference forecast period. The resulting incentive thresholds applied were a range of values starting with $0.075/m^3 in 2019 and declining to slightly less than $0.02/m^3 in the terminal year of the reference forecast period (2038). Table 7-1 details the specific incentive costs applied to both the natural gas and electric measures.

Table 7-1. Constrained Scenario Incentive Approach

Electricity	Natural Gas
Levelized Cost Threshold Approach: Threshold = 2.5 cents/kWh	Levelized Cost Threshold Approach: Threshold determined by targeting a program cost of $80M/year in the first five years, and averaging $80M/year over the last 15 years of the potential study[60]

Source: Navigant analysis

Maximum Achievable Scenario (Scenario B)

In the Maximum Achievable Scenario, Navigant set incentives to 100% of the incremental cost of a measure and the adoption parameters to reflect the impact of an ideal program design. Using the adoption parameters of an ideal program is meant to simulate more aggressive and effective marketing campaigns, resulting in steeper adoption curves (faster adoption). This scenario serves as an upper bound for what potential may be possible when considering market factors. This can also be used to

---

[60] The program cost values were provided by the OEB, derived from the DSM budgets for 2016-2020.

compare against other studies with maximum achievable scenarios as comparisons of the constrained scenarios with other studies may be confounded by differences in the assumed constraints.

Table 7-2 details the specific incentive costs applied to both the natural gas and electric measures.

Table 7-2. Maximum Scenario Incentive Approach

Electricity	Natural Gas
Percent of Incremental Cost Approach: 100% of incremental cost was covered by incentives	Percent of Incremental Cost Approach: 100% of incremental cost was covered by incentives

Source: Navigant analysis

Semi-Constrained Scenario (Scenario C)

The semi-constrained scenario definition was developed to deliver an estimate of potential that fell somewhere in between the constrained potential (Scenario A) and the maximum achievable potential (Scenario B).

The constraint applied to the electricity potential was to deliver a portfolio average incentive level of approximately 2.5 cents/lifetime kWh (2018 dollars) savings over the potential reference forecast period. Specifically, this means that when translating all incentive dollars spent over the potential reference forecast period into 2018 terms, then dividing by the lifetime kWh savings of all measures installed during this period, the result is approximately 2.5 cents/lifetime kWh. Navigant mitigated against large swings in incentive spending by splitting the period of analysis into two 10-year periods and calibrated the potential estimation model to ensure that the average levelized incentive cost was approximately 2.5 cents/kWh of lifetime savings. This approach required applying an incentive cap of $1.00/lifetime kWh across all years.

With respect to natural gas energy potential, the goal of this scenario was to determine how much it would cost to achieve a more aggressive savings level compared to the results of the program cost constrained scenario (Scenario A). Specifically, the goal was to determine how much it would cost to achieve the Scenario A potential in addition to part of the 2030 greenhouse gas emission reduction scenario specified for expansion of natural gas conservation programs in the Ontario Ministry of the Environment, Conservation and Parks' Environment Plan.[61] The resulting incentive threshold applied was $0.10/m^3. Table 7-3 details the specific incentive costs applied to both the natural gas and electric measures.

Table 7-3. Semi-Constrained Scenario Incentive Approach

Electricity	Natural Gas
Levelized Cost Threshold Approach: Threshold determined by targeting an average incentive payment of 2.5 cents/lifetime kWh of savings in both the first 10 years and last 10 years of the potential reference forecast period	Levelized Cost Threshold Approach: Threshold determined by targeting a potential savings value in 2030 of Scenario A's potential in 2030 plus 25% of the Environment Plan greenhouse gas emission reduction scenario for expansion of natural gas conservation programs

Source: Navigant analysis

---

[61] Ontario Ministry of Environment, Conservation and Parks, *Preserving and Protecting our Environment for Future Generations: A Made-in-Ontario Environment Plan*, 2018
https://prod-environmental-registry.s3.amazonaws.com/2018-11/EnvironmentPlan.pdf

Demand Targeted Scenario (Scenario D)

This scenario was designed for electricity only, specifically to determine the impact on electric energy and demand savings of providing incentives based on demand savings as opposed to energy savings. Only measures that deliver peak demand savings were included in this potential scenario. Table 7-4 details the specific administrative and incentive costs applied to both the natural gas and electric measures.

Table 7-4. Demand-Targeted Scenario Incentive Approach

Electricity	Natural Gas
Levelized Cost Threshold Approach: Threshold =$123/kW-year[62] of lifetime peak demand savings.	N/A

Source: Navigant analysis

In comparing the estimated program costs across programs, care should be taken in comparing Scenario D with other electric potential scenarios (e.g., Scenario A). For scenarios A, B, and C, all dual fuel measures (e.g., insulation, adaptive thermostats installed in homes with natural gas heating and electric space cooling), all program costs are assumed to flow from the OEB; incentive and administrative costs for dual fuel measures appear in the natural gas program cost outputs. For Scenario D, this is not the case: all measures included in this scenario are assumed to have incentive and administrative costs paid by the IESO (and calculated in the fashion described above).

7.2.3 Modelling Measure Interactions

7.2.3.1 Competition Groups

For measures involved in competition groups, an additional computational step is required to compute achievable potential. While the technical potential for a competition group reflects only the measure in that group with the greatest savings potential, all measures in a competition group may be allocated achievable potential based on their relative attractiveness to one another.

For each competition group measure, Navigant computed the relative consumer economics ratio to reflect all costs and savings a consumer would experience if that consumer adopted the measure. Navigant then input this ratio into a logit discrete choice model[63] to allocate market share across the competing measures based on their relative customer economics. Navigant multiplied the resulting market share splits by the maximum achievable potential for the competition group to determine the achievable potential for each individual measure. This methodology ensured the final estimates of achievable potential reflect the relative economic attractiveness of measures in a competition group, and the sum of

---

[62] This incentive threshold of $123/kW-year is the IESO's assumed cost of new generation capacity, based on the levelized capacity cost of a simple cycle gas plant.

Independent Electricity System Operator, *2018 Technical Planning Conference – IESO Response to Stakeholder Comments and Questions*, November 30, 2018

http://www.ieso.ca/-/media/Files/IESO/Document-Library/planning-forecasts/tech-conf/2018-IESO-Responses-to-Technical-Planning-Conference-Comments-Questions-20181130.pdf?la=en

[63] A logit formulation is based on documented consumer decision theory that accounts for consumer preferences in competing choices based on the relative and absolute differences between the choices.

Daniel McFadden and Kenneth Train, "Mixed MNL Models for Discrete Response," *Journal of Applied Econometrics,* Vol. 15, No. 5, 447-470, 2000; and Kenneth Train, *Discrete Choice Methods with Simulation*, (Massachusetts: Cambridge University Press, 2003).

achievable potential from all measures in a competition group reflect the maximum achievable potential of the group.

7.2.3.2 Measure Stacking

As discussed in Chapter 5 and Appendix D.1.1, when two or more measures that impact the same end use energy consumption are installed in the same building, the total savings that can be achieved may be less than the sum of the savings from those measures independently.

The only difference between the achievable and economic potential after considering measure stacking is that now the other considerations of achievable potential such as payback acceptance and rates of adoption are included. No additional considerations were made for evaluating the effects of measure stacking at the achievable potential stage. Specifically, it was assumed that most consumers do not calculate the marginally reduced benefits of installing lighting controls and more efficient lighting prior to purchasing both, and thus no adjustment to the cost-effectiveness or NEIs of stacking measures was made.

7.2.4 Calculating Program Costs

7.2.4.1 Administrative Cost Approaches

Administrative costs are those required to operate a CDM or DSM program outside of the incentive costs, and include things such as program administration personnel, marketing spending, deployment and logistical costs, etc. Administrative costs are, along with the annual sectoral incentive costs, a key output of this analysis.

For the purposes of this potential study, only variable administrative costs were assumed. How administrative costs were applied varied by fuel type and by scenario. The key differentiator is that administrative costs for electric measures were applied as a function of the estimated potential, so as $/kWh (Scenarios A, B, C) or $/kW (Scenario D) adder, whereas for natural gas measures administrative costs were applied as a function of incentives. In most studies, these two approaches would deliver more or less equivalent results. The reason why this potential study applies two different approaches for electricity and natural gas measures is because there are a material number of low-cost (or no-incremental-cost) electricity measures – in this case, applying administrative costs as a percentage of incentive costs (Navigant’s standard approach) would understate overall program costs.

The specifics of how the administrative costs were applied can be found in Table 7-5.

Table 7-5. Administrative Costs Approaches by Scenario

Scenario	Electricity	Natural Gas
Energy and Program Cost Targeted Scenarios (Scenarios A, B, and C)	Variable Administrative Costs Only Approach: Costs set to scale with potential as 0.5 cents/lifetime kWh of savings	Variable Administrative Costs Only Approach: Costs set to scale with incentives as 40% of incentives[64]
Demand Targeted Scenario (Scenario D)	Variable Administrative Costs Only Approach: Costs set to scale with potential as ~$35/kW-year of lifetime peak demand savings[65]	N/A

Source: Navigant analysis

7.2.4.2 Net Savings Study

Since the reference forecast consumption levels in this potential study are net of natural conservation, the potential results shown in this report do not include savings achieved by any free riders that may participate in a program, or costs to deliver the program to those free riders. As noted Chapter 4, free riders are consumers that participate in an energy efficiency programs to receive an incentive for installing efficient measures, even though they would have installed them without an incentive. Since most programs will have at least some free riders, the program administrator incurs additional incentive and administrative costs to deliver to these customers without achieving any additional energy efficiency potential beyond what would have happened naturally (i.e., without a program in place). The portion of participants in a program that are free riders can vary widely depending on program design, delivery, and other factors (e.g., incentive size, target customer type, enrollment requirements, applicant screening processes, etc.). Program design, delivery, and assessment of free ridership are beyond the scope of this potential study.

The program costs in each achievable scenario presented below represent the cost of energy efficiency program portfolios to non-free rider participants. The program costs do not include fixed portfolio overheads, which also vary depending on program design and delivery (e.g., number of local contractors required, marketing costs, whether a call centre is used, evaluation & measurement activities, etc.).

When proposing a budget for a future DSM or CDM portfolio or program based on the potential scenarios included in this potential study, a program delivery agent should consider incremental program costs to account for future program net-to-gross (NTG) ratios and fixed portfolio overhead costs with supporting rationale and evidence. For example:

Equation 7-2. Calculating Gross Budget from Net Program Cost Values

$$A. \mathit{Annual\ Program\ Budget\ for\ Future\ DSM\ Portfolio} = \frac{\mathit{Net\ Program\ Administrator\ Cost\ from\ APS\ Study}}{\mathit{Estimated\ NTG\ Ratio}} + \mathit{Overhead}$$

$$B. \frac{\$80M}{75\%} + \$10M = \$117M$$

---

[64] These values are based on a review of 2016 DSM administrative costs and incentive levels.

[65] This value selected such that administrative costs for Scenario D as a proportion of total costs were approximately in line with Scenario A administrative costs as a proportion of total costs.

Where NTG ratio (%) = 1 – Free Riders (%) if there is no spillover. Free ridership is the main component of the NTG calculation. Spillover, in which customers are influenced by a program but do not receive an incentive, may also be considered part of NTG, but was not assessed as part of this potential study.

7.3 Results

This section provides the achievable savings potential calculated by the model at varying levels of aggregation. Results are shown by sector, customer segment, end use category, and highest-impact measures. This will include natural gas and electric energy results.

In some cases, the format of how results are presented in this chapter differs from those presented in the chapters related to technical and economic potential. This difference is driven by two considerations:

- To allow (in the sections related to sectoral potential) the reader to easily compare results across scenarios and against the technical and economic potential results.
- For concision—unlike for technical and economic potential, four iterations of each set of results exist, and a comprehensive presentation of these would substantially increase the length of the chapter.

Comprehensive data tables used to derive all the results below (and those not included here) are available as part of the supporting data files available online.

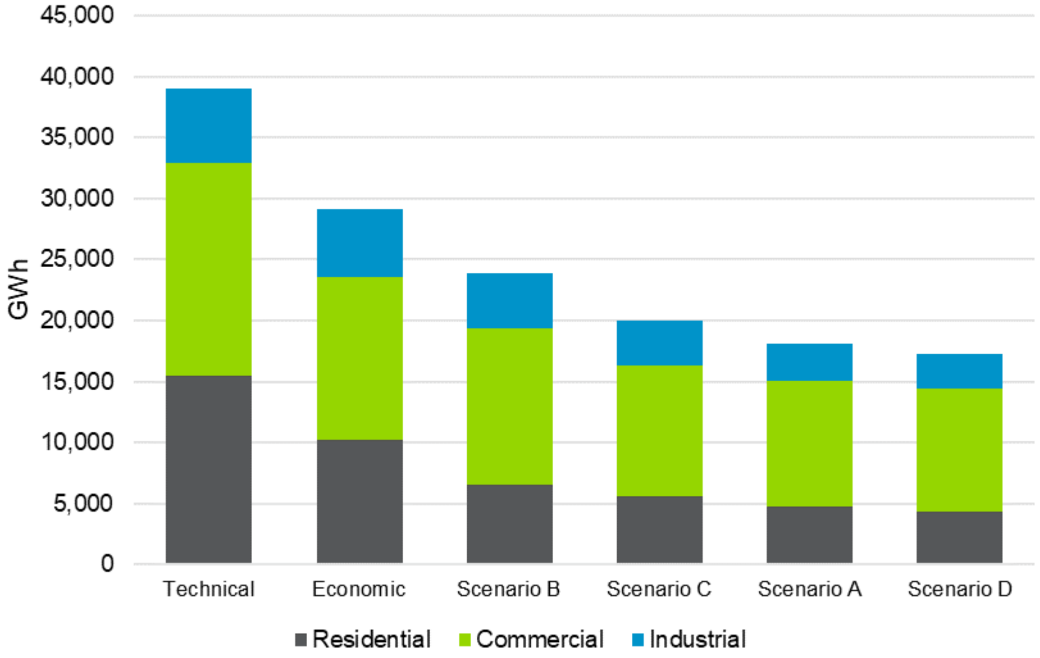
7.3.1 Provincial Results by Scenario

This section compares the achievable savings potential of each scenario.

7.3.1.1 Potential by Sector and Scenario

Figure 7-2 shows the total achievable electric energy savings potential in 2038 for all measures installed over the potential reference forecast period broken down by sector and scenario. By 2038, Scenarios B, C, A, and D reach 82%, 69%, 62%, and 59% of the economic potential, respectively. Within each scenario, the commercial sector provides the greatest contribution to achievable potential and is responsible for approximately between 54% and 59% (depending on the scenario) of the total potential.

Figure 7-2. Electric Energy Achievable Savings Potential by Sector and Scenario in 2038 (GWh)



Source: Navigant analysis

The potential values for each sector and each potential type shown in the graph above are also provided in Table 7-6 for 2023, 2030, and 2038.

Table 7-6. Electric Energy Potential by Scenario (GWh)

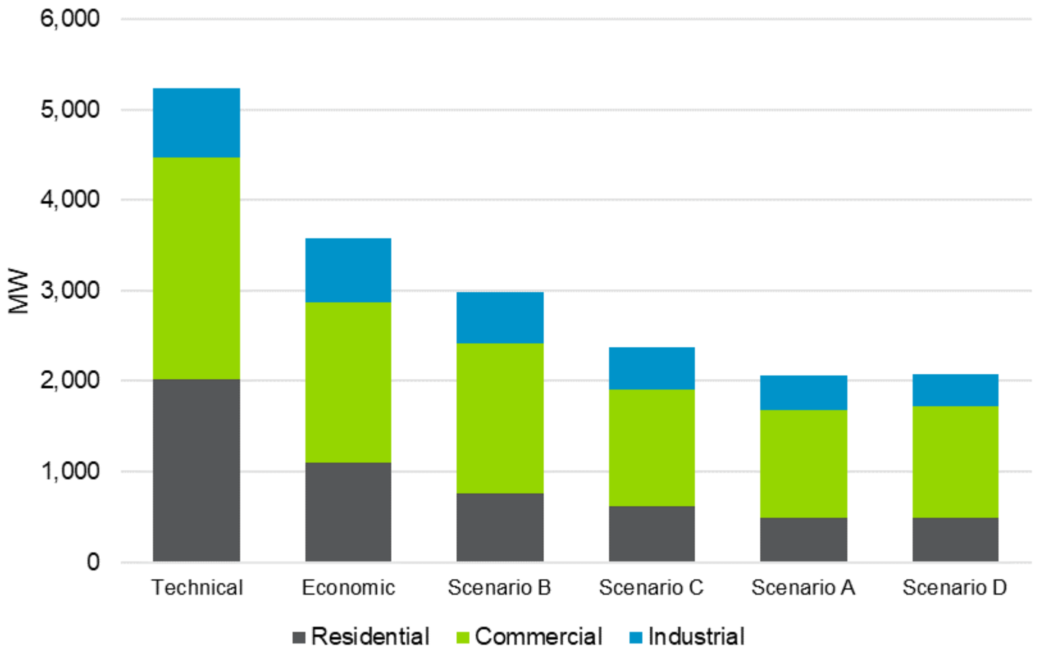
Year	Potential Type	Residential	Commercial	Industrial
2023	Technical	11,796	14,701	5,024
2023	Economic	6,514	11,963	3,618
2023	Scenario B	1,869	4,011	1,034
2023	Scenario C	1,322	3,169	619
2023	Scenario A	1,181	3,051	598
2023	Scenario D	1,112	2,951	586
2030	Technical	14,037	16,444	5,639
2030	Economic	7,856	13,069	4,819
2030	Scenario B	4,436	9,644	3,052
2030	Scenario C	3,306	7,592	2,020
2030	Scenario A	2,872	7,273	1,748
2030	Scenario D	2,630	7,043	1,661
2038	Technical	15,509	17,464	6,070
2038	Economic	10,236	13,283	5,598
2038	Scenario B	6,563	12,804	4,479
2038	Scenario C	5,598	10,754	3,623
2038	Scenario A	4,722	10,331	3,022

Year	Potential Type	Residential	Commercial	Industrial
2038	Scenario D	4,292	10,143	2,832

Source: Navigant analysis

Figure 7-3 shows the total achievable electric summer peak demand savings potential in 2038 for all measures installed over the potential reference forecast period broken down by sector and scenario. By 2038, Scenarios B, C, A, and D reach 83%, 66%, 58%, and 58% of the economic potential, respectively. Within each scenario, the commercial sector provides the greatest contribution to achievable potential and is responsible for between 55 and 59% of total provincial potential.

Figure 7-3. Electric Summer Peak Demand Achievable Savings Potential by Sector and Scenario in 2038 (MW)



Source: Navigant analysis

The potential values for each sector and each potential type shown in the graph above are also provided in Table 7-7 for 2023, 2030, and 2038.

Table 7-7. Electric Summer Peak Demand Potential by Scenario (MW)

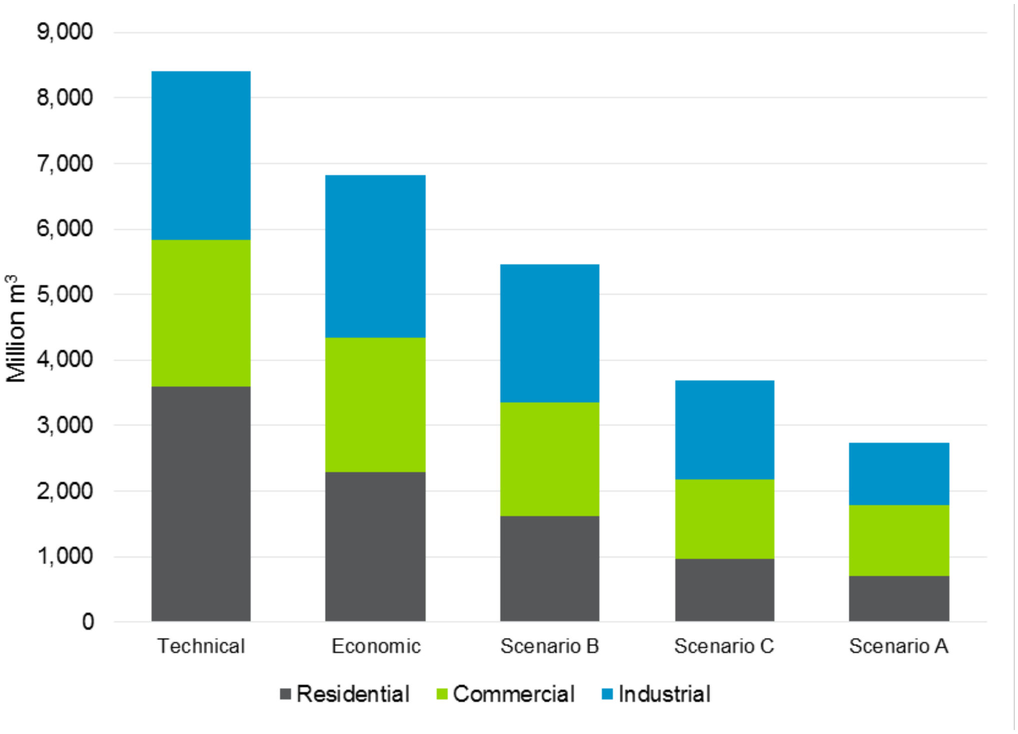
Year	Potential Type	Residential	Commercial	Industrial
2023	Technical	1,402	2,016	641
2023	Economic	730	1,581	464
2023	Scenario B	195	475	132
2023	Scenario C	122	347	79
2023	Scenario A	102	326	75
2023	Scenario D	103	323	75
2030	Technical	1,768	2,267	716
2030	Economic	885	1,728	604

Year	Potential Type	Residential	Commercial	Industrial
2030	Scenario B	500	1,218	386
2030	Scenario C	345	884	256
2030	Scenario A	282	822	219
2030	Scenario D	283	820	213
2038	Technical	2,026	2,439	769
2038	Economic	1,094	1,781	702
2038	Scenario B	763	1,654	563
2038	Scenario C	616	1,297	455
2038	Scenario A	490	1,194	377
2038	Scenario D	494	1,224	360

Source: Navigant analysis

Figure 7-4 shows the total natural gas energy achievable savings potential for each sector and scenario in 2038. By 2038, Scenarios B, C, and A reach 80%, 54%, and 40% of the economic potential, respectively. Within Scenarios B and C, the industrial sector is the greatest contributor to provincial potential and is responsible for approximately 40% of the total potential. However, in Scenario A when the program costs are constrained, the commercial sector overtakes the industrial sector as the greatest contributor to provincial potential providing 39% of the total potential. This change is due to the lower incentive levels Given the high cost of industrial equipment and steep payback acceptance curve for the sector, reducing incentives significantly reduces the industrial potential.

Figure 7-4. Natural Gas Energy Achievable Savings Potential by Sector and Scenario in 2038 (Million m^3)



Source: Navigant analysis

The potential values for each sector and each potential type shown in the graph above are also provided in, Table 7-8 for 2023, 2030, and 2038.

Table 7-8. Natural Gas Potential by Scenario (Million of m^3)

Year	Potential Type	Residential	Commercial	Industrial
2023	Technical	3,375	1,676	2,123
2023	Economic	2,145	1,526	1,995
2023	Scenario B	337	377	551
2023	Scenario C	162	186	274
2023	Scenario A	140	178	225
2030	Technical	3,513	1,982	2,369
2030	Economic	2,215	1,816	2,237
2030	Scenario B	977	1,134	1,523
2030	Scenario C	517	624	828
2030	Scenario A	410	571	561
2038	Technical	3,594	2,239	2,568
2038	Economic	2,281	2,066	2,467
2038	Scenario B	1,620	1,736	2,102
2038	Scenario C	957	1,212	1,517
2038	Scenario A	713	1,072	956

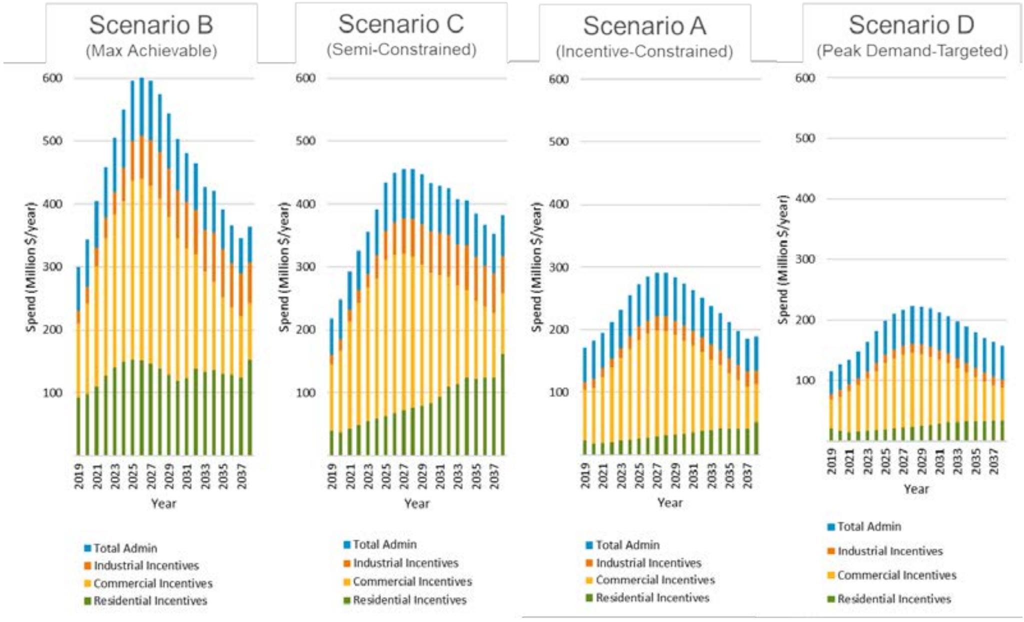
Source: Navigant analysis

7.3.1.2 Program Costs by Sector and Scenario

Figure 7-5 shows the total electric energy achievable program cost for each sector and scenario. As expected, Scenario B (max achievable) is the most expensive. This scenario covers 100% of the measure cost with incentives, Scenario A (constrained) is the least costly energy-focused scenario, and Scenario C (semi-constrained) falls in the middle. Scenario D, the demand-focused scenario (includes only measures that deliver summer peak demand savings and applies incentives on the basis of demand savings) is the least costly of all four scenarios. Note that the program costs for Scenario D are not entirely comparable to those of Scenarios A, B, and C, as the electric program costs in Scenario D's case includes costs associated with dual-fuel measures whereas in Scenarios A, B, and C the dual-fuel spend is captured within the natural gas program costs. [66]

For all scenarios, the commercial sector accounts for the majority of the incentive spend in each scenario, tracking the fact that the sector also accounts for the most electric potential in all scenarios.

Figure 7-5. Electric Energy Achievable Cost by Sector and Scenario (Million $/year)



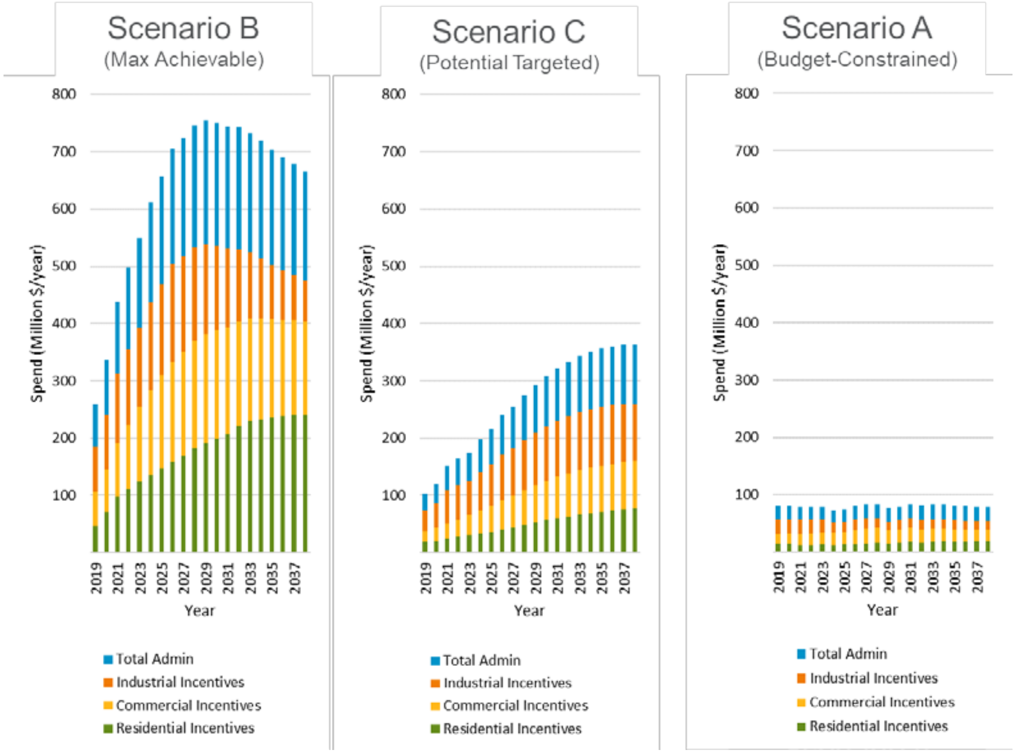
Source: Navigant analysis

---

[66] Measures incentive costs are tracked by the primary fuel saved by the measure in scenarios where both fuels' savings are considered. In Scenario D, only electricity savings are considered for output, so incentive costs are all counted as accruing to electricity measures.

Figure 7-6 shows the total cost to achieve each natural gas achievable potential scenario. Like the electricity scenarios, Scenario B is the most expensive as it covers 100% of the measure cost with incentives, Scenario A is the cheapest given that it is constrained to current DSM budget levels, and Scenario C falls in the middle. The reason Scenario A's program costs appear flat (in contrast to the other scenarios) over time is by construction. Recall that the natural gas Scenario A constraint was to ensure that the total program cost should be $80M/year in the first five years and average $80 million/year over the last 15 years. On the other hand, Scenarios B and C costs increase over time as they are unconstrained. Scenario B's spend begins to decline in the later years because that scenario has reached and surpassed the inflection point at which the maximum adoption in a single year is achieved (the middle of the S-shaped adoption curve) and annual adoption (and thus cost) begins to decrease afterward.

Figure 7-6. Natural Gas Energy Achievable Program Cost by Sector and Scenario (Million $/year)



Source: Navigant analysis

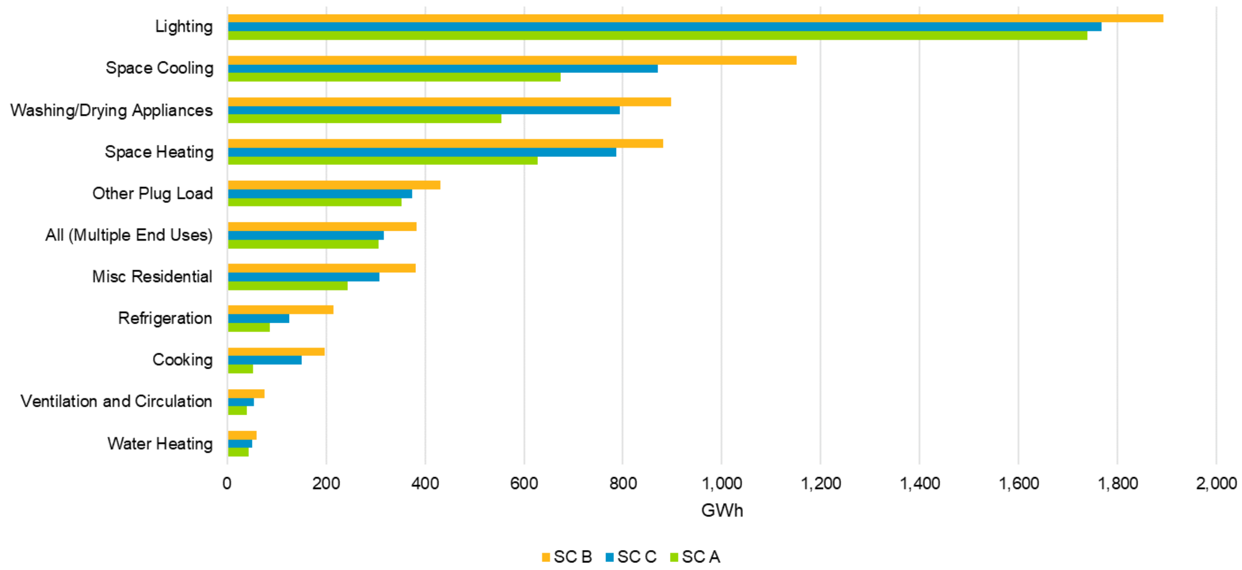
7.3.2 Residential Potential Results

7.3.2.1 Results by End Use

Figure 7-7 shows the total electric energy achievable savings potential for each end use and scenario in 2038. While most end uses have similar values across scenarios, there is a relatively little increase in potential from Scenario A to Scenario B for all end uses except the washing/drying appliances, space cooling, and cooking end uses.

The reason for this is that in most of the end uses the consumer levelized unit energy cost of the measures are quite low: even in Scenario A (with the lowest LUEC incentive cap) a very high proportion of these measures will receive incentives very close to 100% of the incentive cost. Increasing the incentive cap only materially affects end uses where there is a wider distribution of consumer LUECs, specifically where there are measures that will benefit from a higher incentive cap.

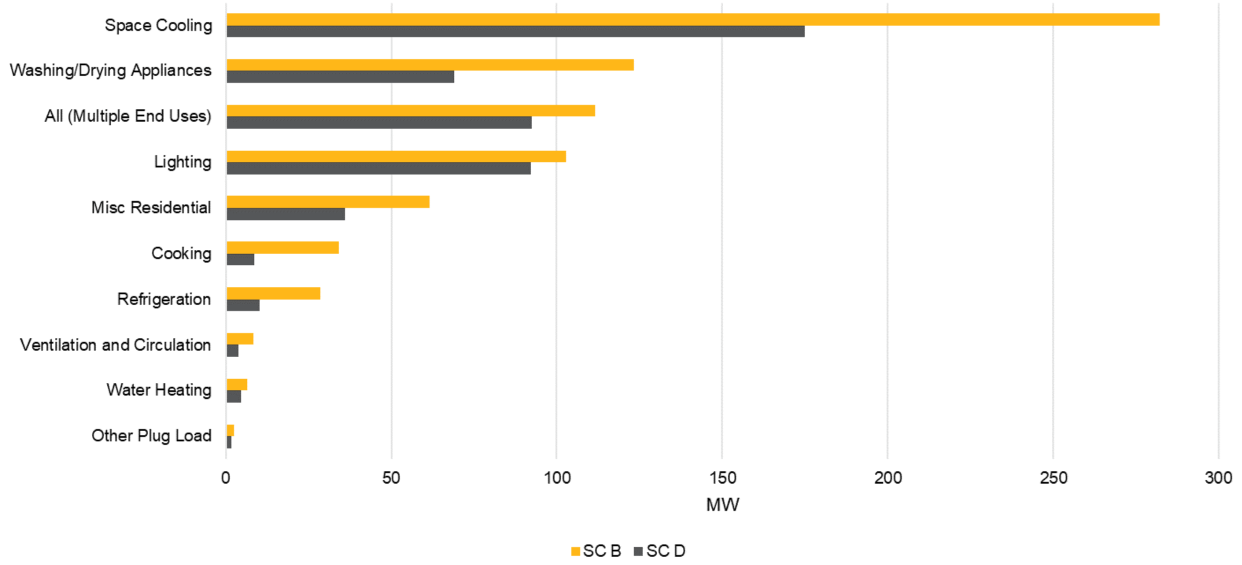
Figure 7-7. Electric Energy Achievable Savings Potential by End Use and Scenario in 2038 (GWh)



Source: Navigant analysis

Figure 7-8 shows the total electric summer peak demand achievable savings potential for each end use and Scenarios B and D in 2038. Although the lighting end use produced the highest amount of electric energy savings, the space cooling end use was responsible for the greatest reduction of demand. This is due to the potential study defining peak demand as a summer peak, thus space cooling has much more of its consumption coincident with the peak demand than that of lighting.

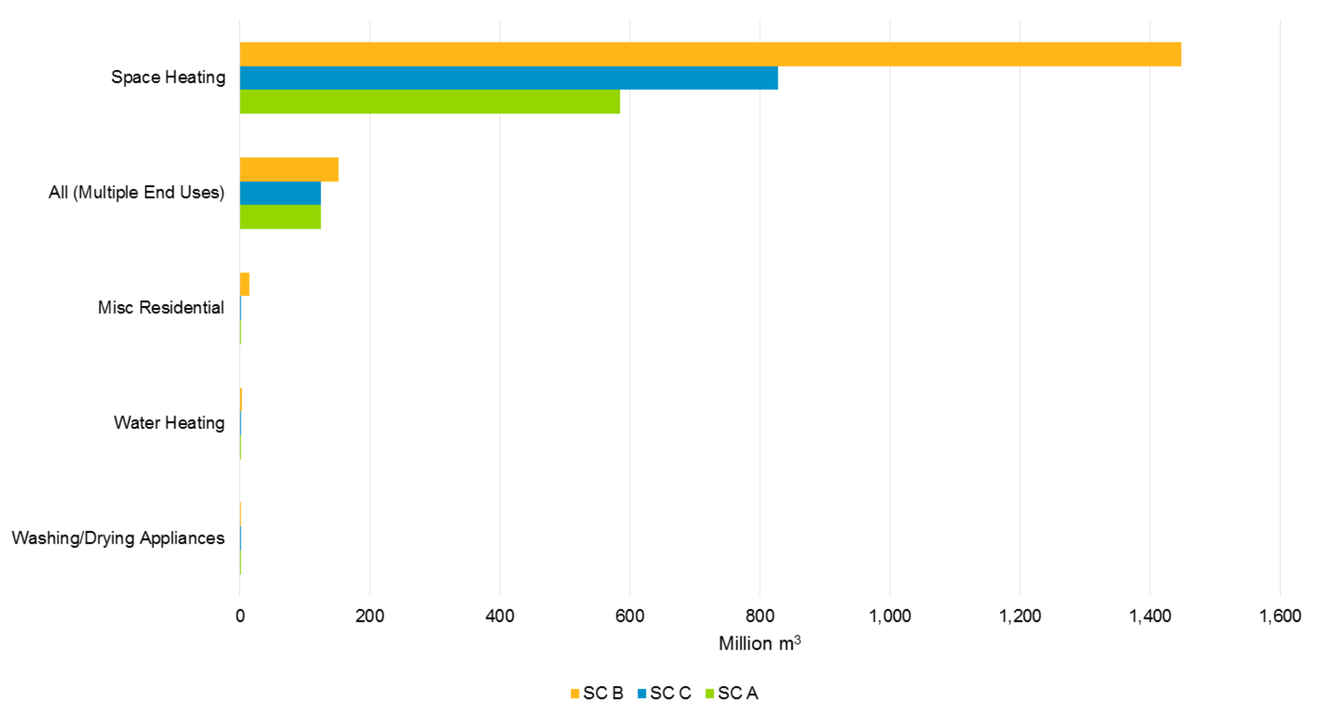
Figure 7-8. Electric Summer Peak Demand Achievable Savings Potential by End Use and Scenario in 2038 (MW)



Source: Navigant analysis

Figure 7-9 shows the total natural gas energy achievable savings potential for each end use and scenario in 2038. As expected, space heating has the highest potential as a percent of the reference forecast as this was the most cost-effective end use observed within the economic potential analysis.

Figure 7-9. Natural Gas Energy Achievable Savings Potential by End Use and Scenario in 2038 (Million m^3)



Source: Navigant analysis

7.3.2.2 Results by Measure

Table 7-9 presents the top 20 residential electricity measures of Scenario A in 2038 ranked by achievable potential. Of the top five measures, three (ENERGY STAR A Line, Ductless Mini-Split, and ENERGY STAR Clothes washer) were also in the group of top five contributors to residential economic potential. The two measures that dropped out of the top five economic potential measures were Smart Power Bar and ENERGY STAR LED Bulbs General Purpose LEDs.

The Smart Power Bar the measure that delivered the most economic potential of any measure in 2038. The reason it does not figure in the top five achievable potential measures is because it only becomes cost-effective in 2038. As an RET measure this means that in the economic potential all possible installations are made as soon as it becomes economic (it delivers no economic potential in 2038). In the achievable potential scenarios, however, adoption is subject to the awareness and ability curve, resulting in only a relatively small amount of projected uptake for the achievable potential scenarios in 2038. The ENERGY STAR LED Bulbs General Purpose LEDs, despite not being amongst the top five largest contributors to achievable potential are the sixth-highest contributor.

Note that, as with the measure-level potential presented in the technical and economic potential chapters, all measure-level potential presented below is *after* the application of competition groups.

Table 7-9. Top 20 Measures for Electric Energy Achievable Savings Potential for Scenario A in 2038 (GWh)

Measure Rank	Measure Name	Potential (GWh)	% of Pot.
1	ENERGY STAR LED Specialty Bulbs	627	13%
2	Ductless Mini-Split Heat Pump	476	10%
3	ENERGY STAR Clothes Washer	473	10%
4	ENERGY STAR A Line, PAR, MR Lamps	320	7%
5	Car Block Heater Timer	307	7%
6	ENERGY STAR LED Bulbs General Purpose LEDs	266	6%
7	Variable Speed Pool Pump Motor	244	5%
8	Building Recommissioning, Operations and Maintenance (O&M) Improvements	237	5%
9	ENERGY STAR Torchiere	196	4%
10	Adaptive Thermostat	153	3%
11	ENERGY STAR Air Source Heat Pump	142	3%
12	Air Sealing	122	3%
13	Basement Wall Insulation	120	3%
14	Comprehensive Draft Proofing	117	2%
15	LED Parking Lot Fixture	87	2%
16	ENERGY STAR Clothes Dryer	77	2%
17	ENERGY STAR Light Fixture	65	1%
18	Occupancy Sensors MF	64	1%
19	Smart Burners	52	1%
20	Refrigerator Recycling	49	1%

Source: Navigant analysis

Table 7-10 presents the top 20 residential natural gas measures of Scenario A in 2038 ranked by achievable potential. Four of the top five measures seen in economic potential remain in the top five in achievable potential. The one measure that dropped out of the top five was heat recovery ventilator, although it remains in the list at number 14.

Table 7-10. Top 20 Measures for Natural Gas Energy Achievable Savings Potential for Scenario A in 2038 (Million m^3)

Measure Rank	Measure Name	Potential (Mm^3)	% of Pot.
1	Comprehensive Draft Proofing	142	20%
2	Adaptive Thermostat	118	16%
3	High Efficiency Fireplace with Pilotless Ignition	80	11%
4	Air Sealing	79	11%
5	Advanced BAS/Controllers	61	9%
6	Building Recommissioning, Operations and Maintenance (O&M) Improvements	50	7%

Measure Rank	Measure Name	Potential (Mm^3)	% of Pot.
7	Condensing Make Up Air Unit	43	6%
8	Basement Wall Insulation	34	5%
9	Attic Insulation	23	3%
10	Condensing Boiler	19	3%
11	Demand Control Ventilation	19	3%
12	Home Energy Reports	14	2%
13	High Efficiency Condensing Furnace	12	2%
14	Heat Recovery Ventilator	10	1%
15	Wall Insulation MF	3	0%
16	Duct Insulation MF	2	0%
17	Water Heater Temperature Setback	2	0%
18	Pool Cover	1	0%
19	Duct Insulation	1	0%
20	Floor Insulation	1	0%

Source: Navigant analysis

Table 7-11 presents the top 20 residential electricity measures of Scenario B in 2038 ranked by achievable potential. Four of the top five measures seen in economic potential remain in the top five in achievable potential. The one measure that dropped out of the top five economic potential measures was smart power bar.

Table 7-11. Top 20 Measures for Electric Energy Achievable Savings Potential for Scenario B in 2038 (GWh)

Measure Rank	Measure Name	Potential (GWh)	% of Pot.
1	ENERGY STAR Clothes Washer	693	11%
2	Ductless Mini-Split Heat Pump	560	8%
3	ENERGY STAR LED Bulbs General Purpose LEDs	441	7%
4	ENERGY STAR A Line, PAR, MR Lamps	426	6%
5	Adaptive Thermostat	409	6%
6	ENERGY STAR LED Specialty Bulbs	400	6%
7	Variable Speed Pool Pump Motor	382	6%
8	Car Block Heater Timer	377	6%
9	Building Recommissioning, Operations and Maintenance (O&M) Improvements	296	4%
10	ENERGY STAR Torchiere	241	4%
11	Air Sealing	235	4%
12	Smart Burners	197	3%
13	ENERGY STAR Air Source Heat Pump	192	3%
14	Comprehensive Draft Proofing	150	2%
15	ENERGY STAR Clothes Dryer	137	2%

Measure Rank	Measure Name	Potential (GWh)	% of Pot.
16	Basement Wall Insulation	123	2%
17	Attic Insulation	95	1%
18	ENERGY STAR Light Fixture	94	1%
19	LED Parking Lot Fixture	91	1%
20	Occupancy Sensors MF	88	1%

Source: Navigant analysis

Table 7-12 presents the top 20 residential natural gas measures of Scenario B in 2038 ranked by achievable potential. Four of the top five measures seen in economic potential remain in the top five in achievable potential. The one measure that dropped out of the top five was heat recovery ventilator.

Table 7-12. Top 20 Measures for Natural Gas Energy Achievable Savings Potential for Scenario B in 2038 (Million m^3)

Measure Rank	Measure Name	Potential (Mm^3)	% of Pot.
1	Adaptive Thermostat	287	18%
2	Air Sealing	275	17%
3	Comprehensive Draft Proofing	183	11%
4	High Efficiency Condensing Furnace	122	7%
5	High Efficiency Fireplace with Pilotless Ignition	120	7%
6	Heat Recovery Ventilator	91	6%
7	Condensing Boiler	91	6%
8	Advanced BAS/Controllers	75	5%
9	Condensing Make Up Air Unit	75	5%
10	Attic Insulation	67	4%
11	Building Recommissioning, Operations and Maintenance (O&M) Improvements	62	4%
12	Basement Wall Insulation	56	3%
13	Demand Control Ventilation	34	2%
14	Floor Insulation	22	1%
15	Duct Insulation	18	1%
16	Duct Insulation MF	16	1%
17	Pool Cover	15	1%
18	Home Energy Reports	14	1%
19	Wall Insulation	7	0%
20	Wall Insulation MF	3	0%

Source: Navigant analysis

Table 7-13 presents the top 20 residential electricity measures of Scenario C in 2038 ranked by achievable potential. Three of the top five measures seen in economic potential remain in the top five in achievable potential. The two measures that dropped out of the top five economic potential measures were smart power bar and energy star LED bulbs general purpose LEDs.

Table 7-13. Top 20 Measures for Electric Energy Achievable Savings Potential for Scenario C in 2038 (GWh)

Measure Rank	Measure Name	Potential (GWh)	% of Pot.
1	ENERGY STAR Clothes Washer	653	12%
2	ENERGY STAR LED Specialty Bulbs	627	11%
3	Ductless Mini-Split Heat Pump	476	8%
4	ENERGY STAR A Line, PAR, MR Lamps	320	6%
5	Variable Speed Pool Pump Motor	308	5%
6	Car Block Heater Timer	307	5%
7	Adaptive Thermostat	277	5%
8	ENERGY STAR LED Bulbs General Purpose LEDs	266	5%
9	Building Recommissioning, Operations and Maintenance (O&M) Improvements	238	4%
10	Air Sealing	214	4%
11	ENERGY STAR Torchiere	196	3%
12	Smart Burners	150	3%
13	ENERGY STAR Air Source Heat Pump	142	3%
14	ENERGY STAR Clothes Dryer	137	2%
15	Basement Wall Insulation	124	2%
16	Comprehensive Draft Proofing	121	2%
17	Attic Insulation	93	2%
18	ENERGY STAR Light Fixture	89	2%
19	LED Parking Lot Fixture	87	2%
20	Smart Power Bar	66	1%

Source: Navigant analysis

Table 7-14 presents the top 20 residential natural gas measures of Scenario C in 2038 ranked by achievable potential. Four of the top five measures seen in economic potential remain in the top five in achievable potential. The one measure that dropped out of the top five was heat recovery ventilator.

Table 7-14. Top 20 Measures for Natural Gas Energy Achievable Savings Potential for Scenario C in 2038 (Million m^3)

Measure Rank	Measure Name	Potential (Mm^3)	% of Pot.
1	Adaptive Thermostat	164	17%
2	Comprehensive Draft Proofing	147	15%
3	Air Sealing	128	13%
4	High Efficiency Fireplace with Pilotless Ignition	112	12%
5	Condensing Make Up Air Unit	62	6%
6	Advanced BAS/Controllers	61	6%
7	Basement Wall Insulation	56	6%
8	Attic Insulation	51	5%

Measure Rank	Measure Name	Potential (Mm^3)	% of Pot.
9	Building Recommissioning, Operations and Maintenance (O&M) Improvements	50	5%
10	Condensing Boiler	33	3%
11	Demand Control Ventilation	27	3%
12	High Efficiency Condensing Furnace	20	2%
13	Heat Recovery Ventilator	19	2%
14	Home Energy Reports	14	2%
15	Duct Insulation MF	4	0%
16	Wall Insulation MF	3	0%
17	Pool Cover	2	0%
18	Duct Insulation	2	0%
19	Water Heater Temperature Setback	2	0%
20	Floor Insulation	1	0%

Source: Navigant analysis

Table 7-15 presents the top 20 residential electric summer peak demand measures of Scenario D in 2038 ranked by achievable potential. Differences between the distribution of measures contributing the most electric energy potential and the distribution of measures contributing the most summer peak demand potential are discussed in section 10.1.2 on a sector-by-sector basis.

Table 7-15. Top 20 Measures for Electric Summer Peak Demand Achievable Savings Potential for Scenario D in 2038 (MW)

Measure Rank	Measure Name	Potential (MW)	% of Pot.
1	Ductless Mini-Split Heat Pump	139	21%
2	Building Recommissioning, Operations and Maintenance (O&M) Improvements	69	11%
3	ENERGY STAR Clothes Washer	56	9%
4	Adaptive Thermostat	47	7%
5	ENERGY STAR Air Source Heat Pump	41	6%
6	ENERGY STAR Room Air Conditioner	36	6%
7	Variable Speed Pool Pump Motor	36	6%
8	Basement Wall Insulation	35	5%
9	ENERGY STAR LED Bulbs General Purpose LEDs	24	4%
10	ENERGY STAR LED Specialty Bulbs	23	4%
11	ENERGY STAR A Line, PAR, MR Lamps	17	3%
12	Attic Insulation	14	2%
13	Home Energy Reports	13	2%
14	ENERGY STAR Clothes Dryer	12	2%
15	High Efficiency Chiller (avg of water and air cooled)	12	2%
16	Advanced BAS/Controllers	10	2%
17	ENERGY STAR Torchiere	9	1%
18	Smart Burners	9	1%
19	Occupancy Sensors MF	8	1%
20	Refrigerator Recycling	5	1%

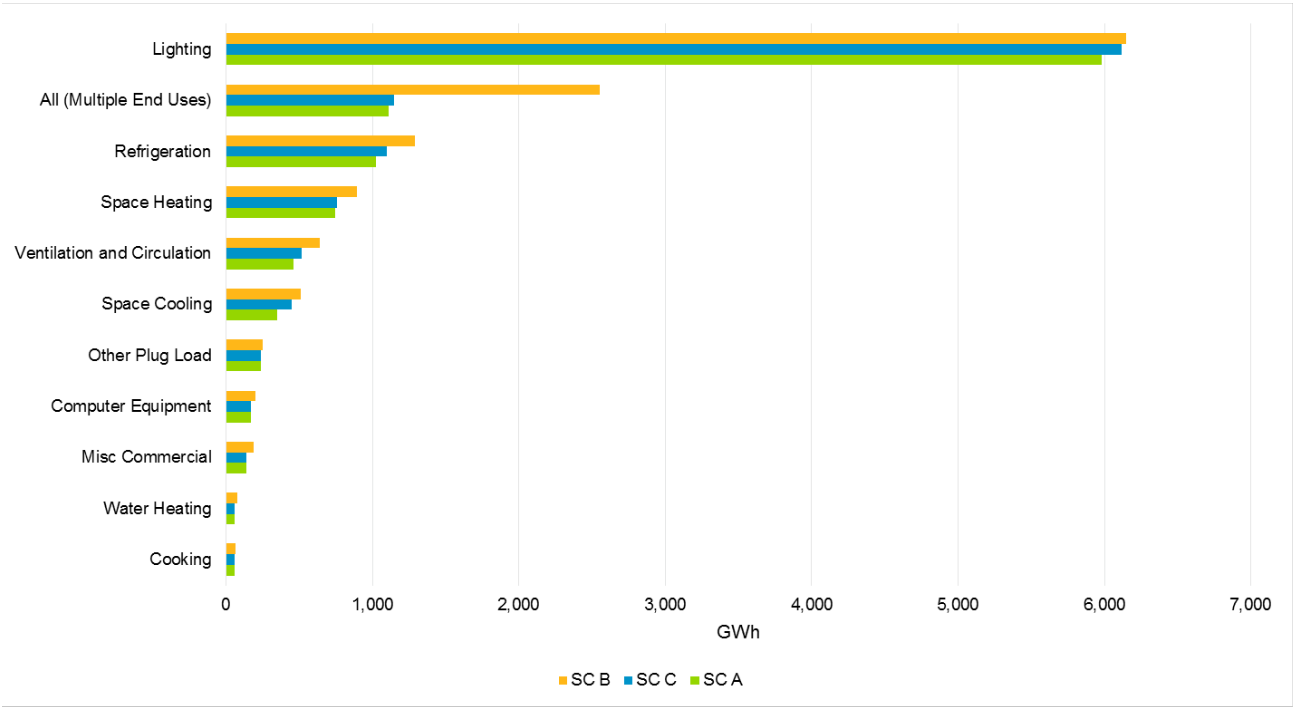
Source: Navigant analysis

7.3.3 Commercial Potential Results

7.3.3.1 Results by End Use

Figure 7-10 shows the total electric energy achievable savings potential for each end use and scenario for each year of the potential reference forecast period. The lighting end use delivers the majority – nearly 60% - of this scenario's potential, a disproportionate amount of the potential given this end use's forecast consumption in 2038 (approximately a third of all consumption). The reason for this is that a very high proportion of commercial lighting measures are actually less expensive than the relevant baseline – with an incremental cost of zero, payback is instantaneous, making these measures very attractive to consumers once motivated to install them through program action.[67]

Figure 7-10. Electric Energy Achievable Savings Potential by End Use and Scenario in 2038 (GWh)



Source: Navigant analysis

Another key feature of this figure is that for all end uses except for the all (multiple end uses) end use, potential doesn't not increase very significantly moving from Scenario A to Scenario B. This is a result of the substantial gap between avoided costs (which determine which measures can be included in the achievable potential) and forecast rates (which determine measure payback, and thus adoption). The avoided costs used in this potential study are considerably lower than the projected rates[68], meaning that measures will only screen as cost-effective when they have extremely attractive paybacks, paybacks so attractive that increases in incentives have relatively little impact on adoption.

The exception to this is the all (multiple end uses) end use. This end use encompasses whole building measures (such as building recommissioning, education and capacity building, etc. During the development of this potential study, Advisory Group members with expertise in this area advised Navigant that considerable opportunity exists in this space and that often the impediment to adoption isn't financial, but rather lack of expertise or interest in undertaking projects like this that are not part of core business functions. To reflect this, Navigant adjusted the ideal program adoption parameters for this end use to capture the fact that considerable opportunity exists in this end use, but that accessing it requires program design (administrative costs) rather than increased incentives.

Figure 7-11 shows the total electric summer peak demand achievable savings potential for each end use for Scenarios B and D in 2038. When summer peak demand potential is considered, it can be seen that

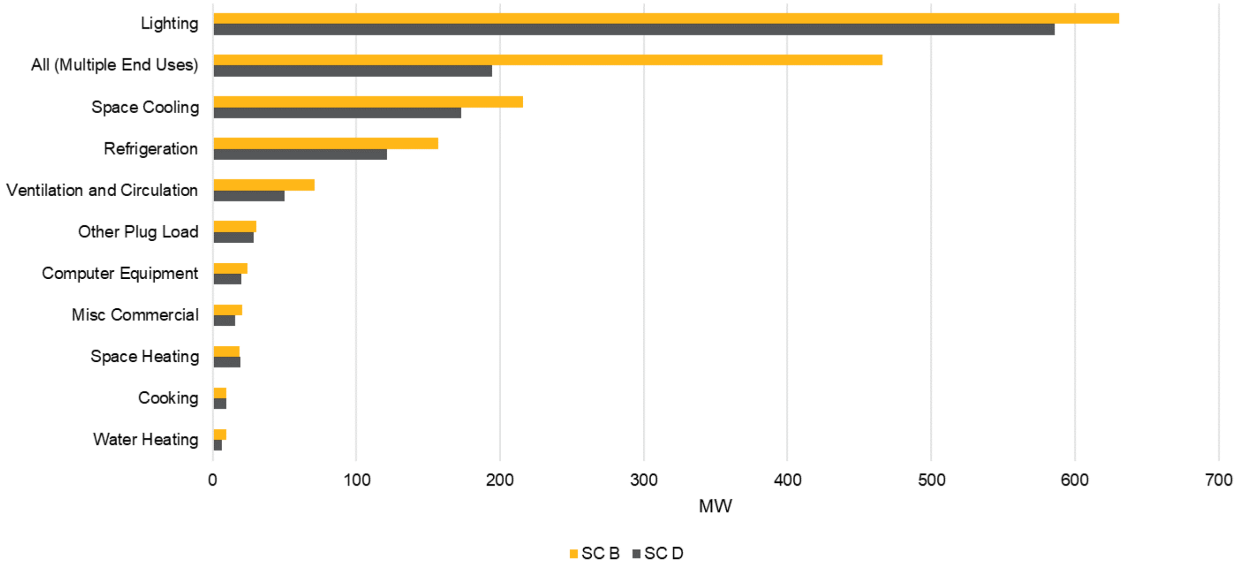
---

[67] Note despite the significant forecast drop in prices for LEDs – the primary factor leading to the dominance by this end use – there is very little natural conservation forecast for this end use in this sector: commercial lighting intensity is forecast by the IESO to fall by only 2% between 2018 and 2038.

[68] For example, projected rates are approximately four times the annual avoided cost benefit of 1 kWh of residential lighting savings.

the gap between the contribution from the lighting end use and the all (multiple end uses) and the space cooling end uses narrows considerably. This is a reflection of the peak coincidence of these various end uses, particularly the all (multiple end uses) end use which is dominated by measures that tend to deliver savings through building HVAC system optimisation (cooling and ventilation).

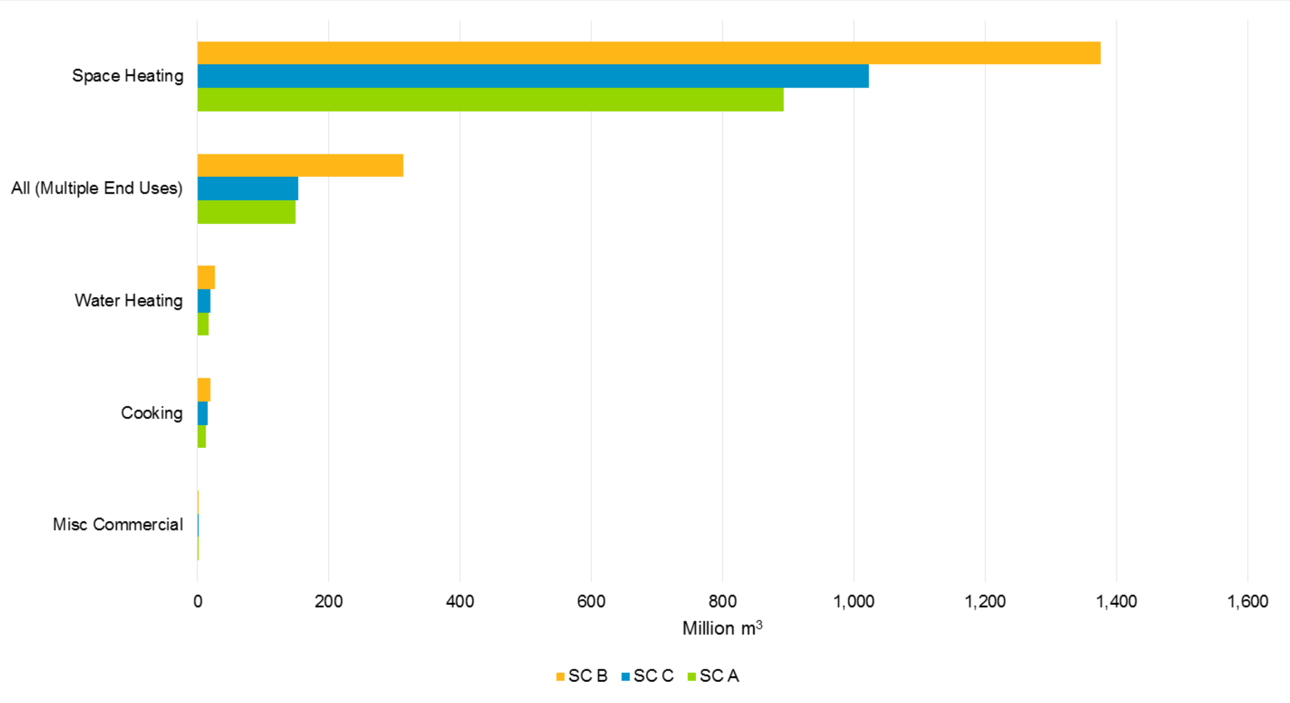
Figure 7-11. Electric Summer Peak Demand Achievable Savings Potential by End Use and Scenario in 2038 (MW)



Source: Navigant analysis

Figure 7-12 shows the total natural gas energy achievable savings potential for each end use and scenario for each year of the potential reference forecast period. As would be expected, space heating delivers by far the largest contribution to sectoral potential. The fact that there is relatively little increase in space heating potential in Scenario C when compared to Scenario A, but a substantial increase moving from Scenario C to B indicates that there is a considerable amount of potential available from very costly (but still cost-effective) commercial heating measures.

Figure 7-12. Natural Gas Energy Achievable Savings Potential by end use and scenario in 2038 (Million m³)



Source: Navigant analysis

7.3.3.2 Results by Measure

Table 7-16 presents the top 20 commercial electricity measures of Scenario A in 2038 ranked by achievable potential. Each of the top five measures seen in economic potential remain in the top five in achievable potential. LED low/high bay obtained the top spot and ranks as the highest impact achievable potential measure.

Table 7-16. Top 20 Measures for Electric Energy Achievable Savings Potential for Scenario A in 2038 (GWh)

Measure Rank	Measure Name	Potential (GWh)	% of Pot.
1	LED Low/High Bay	1,159	11%
2	LED Troffer/Surface/Suspended	1,023	10%
3	ENERGY STAR LED LAMPS (REFLECTOR LAMPs/MR16/PAR 16)	1,005	10%
4	Building Recommissioning, Operations and Maintenance (O&M) Improvements	813	8%
5	LED Replacement Lamp (Tube)	698	7%
6	LED EXTERIOR AREA LIGHTS - LED fixture (200W)	664	6%
7	LED parking lot fixture	633	6%
8	Furnace Tune-Up	451	4%

Measure Rank	Measure Name	Potential (GWh)	% of Pot.
9	LED street light fixture	401	4%
10	High Efficiency Air Source Heat Pump	339	3%
11	Reach-in Shaded Pole to ECM/PSC Evaporator Fan Motor	295	3%
12	Refrigerated Display Case Doors	242	2%
13	Data Centre Storage/Server Virtualisation	236	2%
14	Strip Curtains	219	2%
15	Demand Control Ventilation	173	2%
16	Advanced BAS/Controllers	172	2%
17	Centrally controlled desktop PC/NETWORK PC POWER MANAGEMENT SOFTWARE	167	2%
18	Variable Frequency Drive (VFD)	150	1%
19	VFD on Pumps	140	1%
20	LED or Equivalent Sign Lighting	138	1%

Source: Navigant analysis

Table 7-17 presents the top 20 commercial natural gas measures of Scenario A in 2038 ranked by achievable potential. Four of the top five measures seen in economic potential remain in the top five in achievable potential. The one measure that dropped out of the top five was condensing boiler | std. Demand control ventilation obtained the top spot and ranks as the highest impact achievable potential measure.

Table 7-17. Top 20 Measures for Natural Gas Energy Achievable Savings Potential for Scenario A in 2038 (Million m^3)

Measure Rank	Measure Name	Potential (Mm^3)	% of Pot.
1	Demand Control Ventilation	122	11%
2	Adaptive Thermostats	114	11%
3	Gas Fired Rooftop Units	102	9%
4	Boilers - Advanced Controls (Steam Systems)	98	9%
5	Building Recommissioning, Operations and Maintenance (O&M) Improvements	95	9%
6	Condensing Boiler | Std	76	7%
7	Condensing Make Up Air Unit	67	6%
8	Gas Fired Heat Pump	54	5%
9	Demand Control Kitchen Ventilation	50	5%
10	Air Handler with Dedicated Outdoor Air Systems	47	4%
11	Advanced BAS/Controllers	43	4%
12	Steam System Optimisation	38	4%
13	Furnace Tune-Up	36	3%
14	Destratification	36	3%
15	Condensing Unit Heaters or other Efficient Unit Heating System	26	2%

Measure Rank	Measure Name	Potential (Mm^3)	% of Pot.
16	Wall Insulation	20	2%
17	Education and Capacity Building/Energy Behavior	11	1%
18	Demand controlled Circulating Systems	10	1%
19	Duct Insulation, R8	6	1%
20	High Efficiency Underfired Broilers	6	1%

Source: Navigant analysis

Table 7-18 presents the top 20 commercial electricity measures of Scenario B in 2038 ranked by achievable potential. Each of the top five measures seen in economic potential remain in the top five in achievable potential. Building recommissioning, operations and maintenance (O&M) improvements retained the top spot and ranks as the highest impact achievable potential measure.

Table 7-18. Top 20 Measures for Electric Energy Achievable Savings Potential for Scenario B in 2038 (GWh)

Measure Rank	Measure Name	Potential (GWh)	% of Pot.
1	Building Recommissioning, Operations and Maintenance (O&M) Improvements	1,631	12%
2	LED Low/High Bay	1,220	9%
3	LED Troffer/Surface/Suspended	1,035	8%
4	ENERGY STAR LED LAMPS (REFLECTOR LAMPs/MR16/PAR 16)	1,005	8%
5	LED Replacement Lamp (Tube)	698	5%
6	LED EXTERIOR AREA LIGHTS - LED fixture (200W)	665	5%
7	LED parking lot fixture	633	5%
8	Education and Capacity Building/Energy Behavior	621	5%
9	Furnace Tune-Up	595	5%
10	LED street light fixture	403	3%
11	Refrigerated Display Case Doors	358	3%
12	High Efficiency Air Source Heat Pump	339	3%
13	Reach-in Shaded Pole to ECM/PSC Evaporator Fan Motor	309	2%
14	Demand Control Ventilation	303	2%
15	Advanced BAS/Controllers	298	2%
16	Strip Curtains	269	2%
17	Data Centre Storage/Server Virtualisation	251	2%
18	Centrally controlled desktop PC/NETWORK PC POWER MANAGEMENT SOFTWARE	202	2%
19	Variable Frequency Drive (VFD)	197	2%
20	VFD on Pumps	185	1%

Source: Navigant analysis

Table 7-19 presents the top 20 commercial natural gas measures of Scenario B in 2038 ranked by achievable potential. Four of the top five measures seen in economic potential remain in the top five in achievable potential. The one measure that dropped out of the top five was advanced controls on boilers. Condensing boilers retained the top spot and ranks as the highest impact achievable potential measure.

Table 7-19. Top 20 Measures for Natural Gas Energy Achievable Savings Potential for Scenario B in 2038 (Million m^3)

Measure Rank	Measure Name	Potential (Mm^3)	% of Pot.
1	Condensing Boiler | Std	236	13%
2	Demand Control Ventilation	191	11%
3	Building Recommissioning, Operations and Maintenance (O&M) Improvements	189	11%
4	Gas Fired Rooftop Units	155	9%
5	Adaptive Thermostats	144	8%
6	Boilers - Advanced Controls (Steam Systems)	101	6%
7	Air Handler with Dedicated Outdoor Air Systems	93	5%
8	Condensing Make Up Air Unit	87	5%
9	Gas Fired Heat Pump	73	4%
10	Advanced BAS/Controllers	69	4%
11	Demand Control Kitchen Ventilation	67	4%
12	Education and Capacity Building/Energy Behavior	54	3%
13	Steam System Optimisation	50	3%
14	Destratification	50	3%
15	Condensing Unit Heaters or other Efficient Unit Heating System	50	3%
16	Furnace Tune-Up	47	3%
17	Wall Insulation	27	1%
18	Energy Efficient Laboratory Fume Hood	19	1%
19	Demand controlled Circulating Systems	14	1%
20	Duct Insulation, R8	11	1%

Source: Navigant analysis

Table 7-20 presents the top 20 commercial electricity measures of Scenario C in 2038 ranked by achievable potential. Each of the top five measures seen in economic potential remain in the top five in achievable potential. LED low/high bay obtained the top spot and ranks as the highest impact achievable potential measure.

Table 7-20. Top 20 Measures for Electric Energy Achievable Savings Potential for Scenario C in 2038 (GWh)

Measure Rank	Measure Name	Potential (GWh)	% of Pot.
1	LED Low/High Bay	1,219	11%
2	LED Troffer/Surface/Suspended	1,035	10%

Measure Rank	Measure Name	Potential (GWh)	% of Pot.
3	ENERGY STAR LED LAMPS (REFLECTOR LAMPs/MR16/PAR 16)	1,005	9%
4	Building Recommissioning, Operations and Maintenance (O&M) Improvements	840	8%
5	LED Replacement Lamp (Tube)	698	6%
6	LED EXTERIOR AREA LIGHTS - LED fixture (200W)	664	6%
7	LED parking lot fixture	633	6%
8	Furnace Tune-Up	451	4%
9	LED street light fixture	403	4%
10	High Efficiency Air Source Heat Pump	339	3%
11	Refrigerated Display Case Doors	312	3%
12	Reach-in Shaded Pole to ECM/PSC Evaporator Fan Motor	295	3%
13	Data Centre Storage/Server Virtualisation	236	2%
14	Strip Curtains	219	2%
15	Demand Control Ventilation	216	2%
16	Advanced BAS/Controllers	184	2%
17	LED or Equivalent Sign Lighting	180	2%
18	Centrally controlled desktop PC/NETWORK PC POWER MANAGEMENT SOFTWARE	167	2%
19	Variable Frequency Drive (VFD)	150	1%
20	VFD on Pumps	140	1%

Source: Navigant analysis

Table 7-21 presents the top 20 commercial natural gas measures of Scenario C in 2038 ranked by achievable potential. Four of the top five measures seen in economic potential remain in the top five in achievable potential. The one measure that dropped out of the top five was building recommissioning, operations and maintenance (O&M) improvements. Condensing boilers retained the top spot and ranks as the highest impact achievable potential measure.

Table 7-21. Top 20 Measures for Natural Gas Energy Achievable Savings Potential for Scenario C in 2038 (Million m^3)

Measure Rank	Measure Name	Potential (Mm^3)	% of Pot.
1	Condensing Boiler | Std	143	12%
2	Demand Control Ventilation	138	11%
3	Adaptive Thermostats	114	9%
4	Gas Fired Rooftop Units	104	9%
5	Boilers - Advanced Controls (Steam Systems)	101	8%
6	Building Recommissioning, Operations and Maintenance (O&M) Improvements	98	8%
7	Condensing Make Up Air Unit	72	6%
8	Gas Fired Heat Pump	61	5%

Measure Rank	Measure Name	Potential (Mm^3)	% of Pot.
9	Air Handler with Dedicated Outdoor Air Systems	58	5%
10	Demand Control Kitchen Ventilation	52	4%
11	Advanced BAS/Controllers	45	4%
12	Steam System Optimisation	38	3%
13	Destratification	38	3%
14	Furnace Tune-Up	36	3%
15	Condensing Unit Heaters or other Efficient Unit Heating System	35	3%
16	Wall Insulation	20	2%
17	Education and Capacity Building/Energy Behavior	11	1%
18	Demand controlled Circulating Systems	10	1%
19	Energy Efficient Laboratory Fume Hood	8	1%
20	Duct Insulation, R8	8	1%

Source: Navigant analysis

Table 7-22 presents the top 20 commercial electric summer peak demand measures of Scenario D in 2038 ranked by achievable potential. Differences between the distribution of measures contributing the most electric energy potential and the distribution of measures contributing the most summer peak demand potential are discussed in section 10.1.2 on a sector-by-sector basis.

Table 7-22. Top 20 Measures for Electric Summer Peak Demand Achievable Savings Potential for Scenario D in 2038 (MW)

Measure Rank	Measure Name	Potential (MW)	% of Pot.
1	LED Low/High Bay	157	12%
2	ENERGY STAR LED LAMPS (REFLECTOR LAMPs/MR16/PAR 16)	132	10%
3	LED Troffer/Surface/Suspended	130	10%
4	Building Recommissioning, Operations and Maintenance (O&M) Improvements	102	8%
5	High Efficiency Air Source Heat Pump	99	8%
6	LED Replacement Lamp (Tube)	93	7%
7	Unitary Air-Conditioning Unit	70	5%
8	Advanced BAS/Controllers	57	4%
9	Education and Capacity Building/Energy Behavior	36	3%
10	Adaptive Thermostats	34	3%
11	Reach-in Shaded Pole to ECM/PSC Evaporator Fan Motor	33	3%
12	Data Centre Storage/Server Virtualisation	29	2%
13	Strip Curtains	28	2%
14	Refrigerated Display Case Doors	28	2%
15	Chilled Water Optimisation	25	2%

Measure Rank	Measure Name	Potential (MW)	% of Pot.
16	Furnace Tune-Up	24	2%
17	Centrally controlled desktop PC/NETWORK PC POWER MANAGEMENT SOFTWARE	20	2%
18	LED or Equivalent Sign Lighting	19	1%
19	Demand Control Ventilation	19	1%
20	Variable Frequency Drive (VFD)	16	1%

Source: Navigant analysis

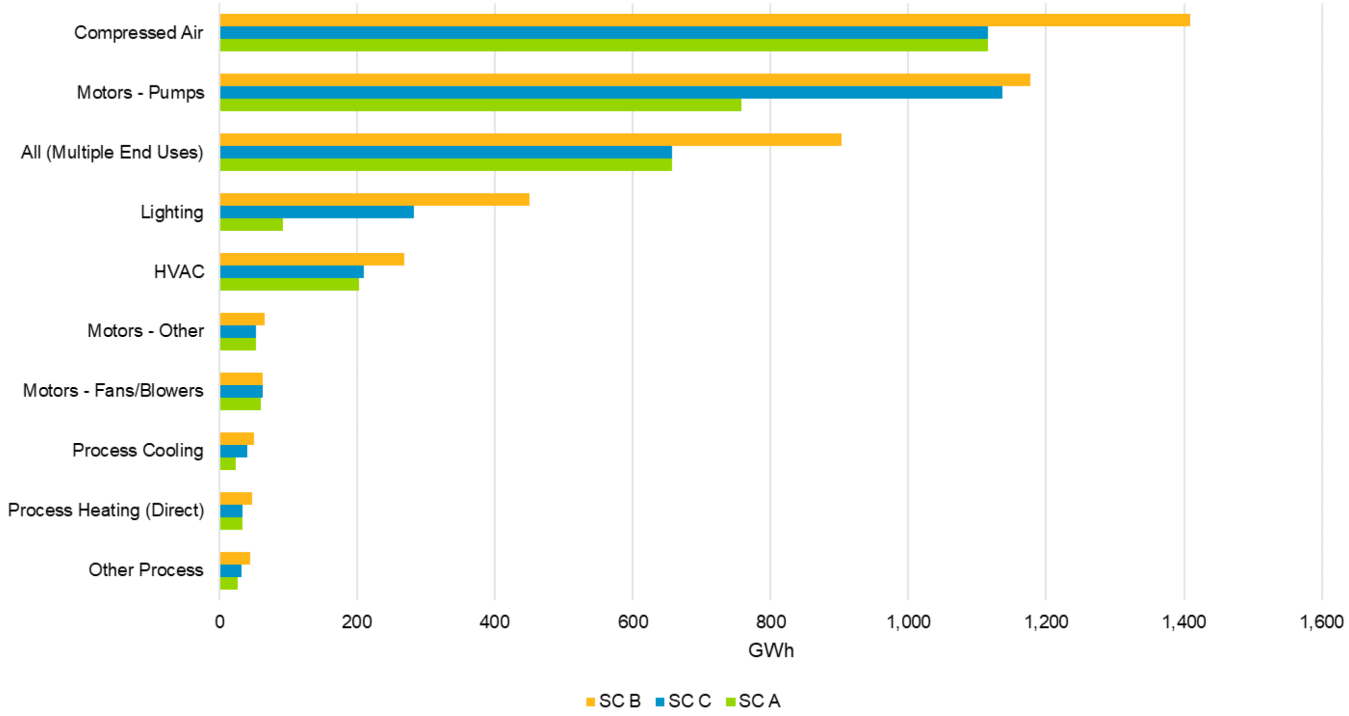
7.3.4 Industrial Potential Results

7.3.4.1 Results by End Use

Figure 7-13 shows the total electric energy achievable savings potential for each end use and scenario projected for 2038. The potential contributions from each of the larger end uses is broadly reflective these end uses' contribution to the reference forecast – motors are the largest contributors to forecast consumption, followed by compressed air – the potential for the lighting end use is disproportionately large. Lighting potential in Scenario B is 16% of forecast consumption in 2038, making this the end use with the second-highest potential as a percentage of forecast consumption. This is due to the attractive payback offered by lighting measures, as noted previously.

A comparison of potential by end use across scenarios provides additional insight into industrial consumers' payback acceptance. Payback acceptance for industrial consumers is highly non-linear, with equilibrium market share falling steeply as payback grows beyond a year or two. Applying this to the figure below, it can clearly be seen that in the compressed air end use there exist some more expensive (but still cost-effective) compressed air measures that industrial consumers won't consider without very high incentives.

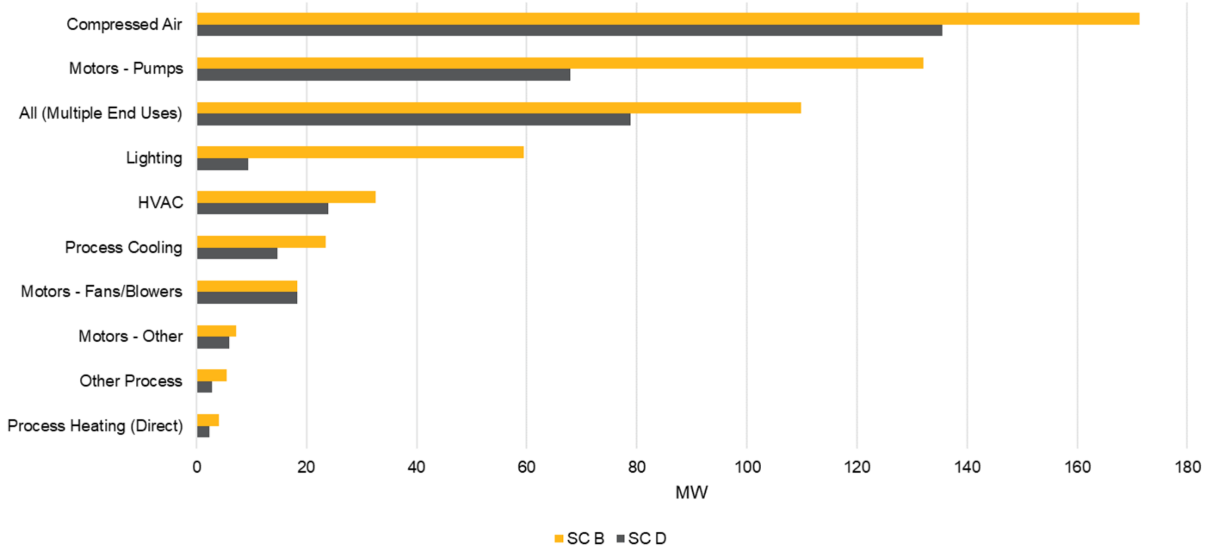
Figure 7-13. Electric Energy Achievable Savings Potential by End Use and Scenario in 2038 (GWh)



Source: Navigant analysis

Figure 7-14 shows the total electric summer peak demand achievable savings potential for each end use and Scenarios B and D in 2038. In addition to the compressed air end use producing the highest amount of electric energy savings, it is responsible for the greatest reduction of demand. This is due to the compressed air energy savings being significantly higher than that of the end uses with greater coincident peak demand. Specifically, even though the potential study defines peak demand as a summer peak and the process cooling and motors – fans/blowers end uses have much more of their consumption coincident with the peak demand than that of compressed air, their savings in the industrial sector aren’t enough to overtake the compressed air end use.

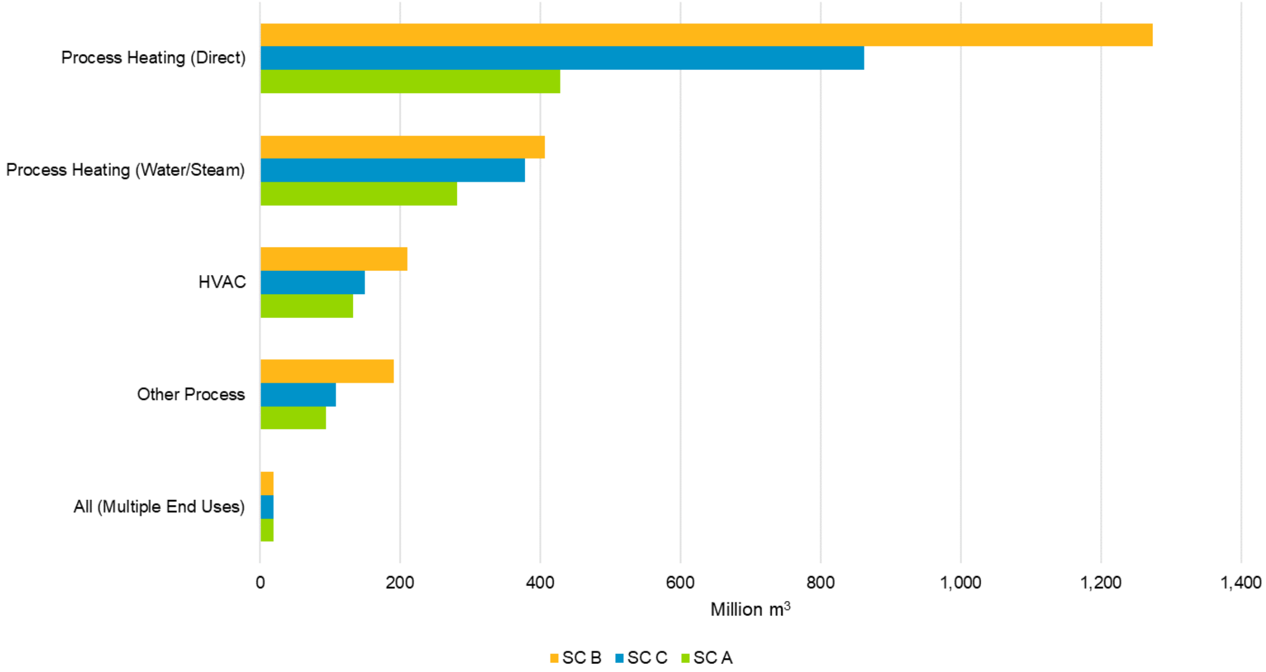
Figure 7-14. Electric Summer Peak Demand Achievable Savings Potential by End Use and Scenario in 2038 (MW)



Source: Navigant analysis

Figure 7-15 shows the total natural gas energy achievable savings potential for each end use and scenario in 2038. For natural gas potential, the magnitude of end use contributions to sectoral potential are very closely aligned with the end use contributions to forecast consumption, process heating accounting for the vast majority, followed by HVAC and then other processes.

Figure 7-15. Natural Gas Energy Achievable Savings Potential by End Use and Scenario in 2038 (Million m³)



Source: Navigant analysis

7.3.4.2 Results by Measure

Table 7-23 presents the top 20 industrial electricity measures of Scenario A in 2038 ranked by achievable potential. Three of the top five measures seen in economic potential remain in the top five in achievable potential. The two measures that dropped out of the top five are high efficiency (HE) lighting and efficient compressed air nozzles. Pump system optimisation retained its top spot and ranks as the highest impact achievable potential measure.

Table 7-23. Top 20 Measures for Electric Energy Achievable Savings Potential for Scenario A in 2038 (GWh)

Measure Rank	Measure Name	Potential (GWh)	% of Pot.
1	Pump System Optimisation	495	16%
2	Air Compressor Optimisation	432	14%
3	Air Leak Survey and Repair	421	14%
4	Recommissioning	298	10%
5	SEM	298	10%
6	Efficient Compressed Air Nozzles	263	9%
7	Pump Equipment Upgrade	212	7%
8	High Efficiency HVAC Fans	177	6%
9	Greenhouse Grow Lights	65	2%
10	Fan System Optimisation	61	2%
11	Process Optimisation (Elec)	60	2%
12	Material Handling Improvements	53	2%
13	Refiner Plate Improvements	31	1%
14	HE Lighting	28	1%
15	Process Heat Recovery	25	1%
16	VAV Conversion Project	18	1%
17	Pulp and Paper Process Improvements	16	1%
18	Improved Controls - Process Cooling	15	1%
19	Process Improvements	11	0%
20	High Efficiency Battery Charger	10	0%

Source: Navigant analysis

Table 7-24 presents the top 20 industrial natural gas measures of Scenario A in 2038 ranked by achievable potential. Three of the top five measures seen in economic potential remain in the top five in achievable potential. The two measures that dropped out of the top five were process heat recovery and high efficiency burners. Process heat improvements retained its top spot and ranks as the highest impact achievable potential measure.

Table 7-24. Top 20 Measures for Natural Gas Energy Achievable Savings Potential for Scenario A in 2038 (Million m^3)

Measure Rank	Measure Name	Potential (Mm^3)	% of Pot.
1	Process Heat Improvements	274	29%
2	Boiler Upgrade	213	22%
3	Recommissioning	133	14%
4	Improved Controls -Process Heating Gas	83	9%
5	Greenhouse Envelope Improvements	76	8%
6	Process Heat Recovery (Gas)	53	6%
7	Insulation - Steam	29	3%
8	Direct Contact Water Heaters	20	2%
9	Insulation - Steam (AG)	15	2%
10	High Efficiency Burners	12	1%
11	High Efficiency HVAC Fans (Gas)	11	1%
12	Steam Turbine Optimisation	9	1%
13	Air Compressor Heat Recovery	7	1%
14	Gas Turbine Optimisation	7	1%
15	HE Stock Tank	5	1%
16	Ventilation Optimisation (Gas)	5	0%
17	Process Optimisation (Gas)	3	0%
18	VAV Conversion Project (Gas)	1	0%
19	Insulation - Steam - Direct	0	0%
20	HE HVAC Controls	0	0%

Source: Navigant analysis

Table 7-25 presents the top 20 industrial electricity measures of Scenario B in 2038 ranked by achievable potential. Three of the top five measures seen in economic potential remain in the top five in achievable potential. The two measures that dropped out of the top five HE lighting and efficient compressed air nozzles. Pump system optimisation retained its top spot and ranks as the highest impact achievable potential measure.

Table 7-25. Top 20 Measures for Electric Energy Achievable Savings Potential for Scenario B in 2038 (GWh)

Measure Rank	Measure Name	Potential (GWh)	% of Pot.
1	Pump System Optimisation	722	16%
2	Air Leak Survey and Repair	595	13%
3	Air Compressor Optimisation	432	10%
4	Recommissioning	421	9%
5	SEM	421	9%
6	Efficient Compressed Air Nozzles	382	9%
7	Pump Equipment Upgrade	333	7%
8	HE Lighting	308	7%

Measure Rank	Measure Name	Potential (GWh)	% of Pot.
9	High Efficiency HVAC Fans	226	5%
10	Greenhouse Grow Lights	143	3%
11	Material Handling Improvements	65	1%
12	Fan System Optimisation	62	1%
13	Pulp and Paper Process Improvements	62	1%
14	Process Optimisation (Elec)	60	1%
15	Refiner Plate Improvements	46	1%
16	Process Heat Recovery	36	1%
17	VAV Conversion Project	26	1%
18	Improved Controls - Process Cooling	21	0%
19	High Efficiency Battery Charger	20	0%
20	Process Improvements	17	0%

Source: Navigant analysis

Table 7-26 presents the top 20 industrial natural gas measures of Scenario B in 2038 ranked by achievable potential. Four of the top five measures seen in economic potential remain in the top five in achievable potential. The one measure that dropped out of the top five was high efficiency burners. Process heat improvements retained its top spot and ranks as the highest impact achievable potential measure.

Table 7-26. Top 20 Measures for Natural Gas Energy Achievable Savings Potential for Scenario B in 2038 (Million m^3)

Measure Rank	Measure Name	Potential (Mm^3)	% of Pot.
1	Process Heat Improvements	693	33%
2	Boiler Upgrade	309	15%
3	Process Heat Recovery (Gas)	292	14%
4	Recommissioning	211	10%
5	Improved Controls -Process Heating Gas	134	6%
6	High Efficiency Burners	131	6%
7	Greenhouse Envelope Improvements	85	4%
8	Insulation - Steam	40	2%
9	High Efficiency HVAC Fans (Gas)	37	2%
10	VAV Conversion Project (Gas)	33	2%
11	Direct Contact Water Heaters	26	1%
12	HE HVAC Controls	23	1%
13	Insulation - Steam (AG)	19	1%
14	Air Compressor Heat Recovery	15	1%
15	Steam Turbine Optimisation	9	0%
16	High Efficiency Furnaces	8	0%
17	HE Stock Tank	7	0%
18	Gas Turbine Optimisation	7	0%

Measure Rank	Measure Name	Potential (Mm^3)	% of Pot.
19	Steam Trap Repair	6	0%
20	Ventilation Optimisation (Gas)	5	0%

Source: Navigant analysis

Table 7-27 presents the top 20 industrial electricity measures of Scenario C in 2038 ranked by achievable potential. Three of the top five measures seen in economic potential remain in the top five in achievable potential. The two measures that dropped out of the top five HE lighting and efficient compressed air nozzles. Pump system optimisation retained its top spot and ranks as the highest impact achievable potential measure.

Table 7-27. Top 20 Measures for Electric Energy Achievable Savings Potential for Scenario C in 2038 (GWh)

Measure Rank	Measure Name	Potential (GWh)	% of Pot.
1	Pump System Optimisation	722	20%
2	Air Compressor Optimisation	432	12%
3	Air Leak Survey and Repair	421	12%
4	Pump Equipment Upgrade	333	9%
5	Recommissioning	298	8%
6	SEM	298	8%
7	Efficient Compressed Air Nozzles	263	7%
8	High Efficiency HVAC Fans	177	5%
9	HE Lighting	169	5%
10	Greenhouse Grow Lights	113	3%
11	Fan System Optimisation	62	2%
12	Process Optimisation (Elec)	60	2%
13	Material Handling Improvements	53	1%
14	Pulp and Paper Process Improvements	42	1%
15	Refiner Plate Improvements	31	1%
16	Process Heat Recovery	25	1%
17	VAV Conversion Project	18	1%
18	High Efficiency Battery Charger	16	0%
19	Improved Controls - Process Cooling	15	0%
20	Ventilation Optimisation	13	0%

Source: Navigant analysis

Table 7-28 presents the top 20 industrial natural gas measures of Scenario C in 2038 ranked by achievable potential. Four of the top five measures seen in economic potential remain in the top five in achievable potential. The one measure that dropped out of the top five was high efficiency burners. Process heat improvements retained its top spot and ranks as the highest impact achievable potential measure.

Table 7-28. Top 20 Measures for Natural Gas Energy Achievable Savings Potential for Scenario C in 2038 (Million m^3)

Measure Rank	Measure Name	Potential (Mm^3)	% of Pot.
1	Process Heat Improvements	471	31%
2	Boiler Upgrade	309	20%
3	Process Heat Recovery (Gas)	205	14%
4	Recommissioning	149	10%
5	Improved Controls -Process Heating Gas	94	6%
6	High Efficiency Burners	81	5%
7	Greenhouse Envelope Improvements	76	5%
8	Insulation - Steam	29	2%
9	High Efficiency HVAC Fans (Gas)	22	1%
10	Direct Contact Water Heaters	20	1%
11	Insulation - Steam (AG)	15	1%
12	Air Compressor Heat Recovery	11	1%
13	Steam Turbine Optimisation	9	1%
14	Gas Turbine Optimisation	7	0%
15	HE Stock Tank	5	0%
16	Ventilation Optimisation (Gas)	5	0%
17	Process Optimisation (Gas)	3	0%
18	VAV Conversion Project (Gas)	3	0%
19	HE HVAC Controls	1	0%
20	Process Heat Recovery (Gas) - HVAC	1	0%

Source: Navigant analysis

Table 7-29 presents the top 20 industrial electric summer peak demand measures of Scenario D in 2038 ranked by achievable potential. Differences between the distribution of measures contributing the most electric energy potential and the distribution of measures contributing the most summer peak demand potential are discussed in section 10.1.2 on a sector-by-sector basis.

Table 7-29. Top 20 Measures for Electric Summer Peak Demand Achievable Savings Potential for Scenario D in 2038 (MW)

Measure Rank	Measure Name	Potential (MW)	% of Pot.
1	Air Compressor Optimisation	52	15%
2	Air Leak Survey and Repair	51	14%
3	Pump System Optimisation	44	12%
4	SEM	36	10%
5	Recommissioning	35	10%
6	Efficient Compressed Air Nozzles	32	9%
7	Pump Equipment Upgrade	19	5%
8	High Efficiency HVAC Fans	19	5%
9	Fan System Optimisation	18	5%

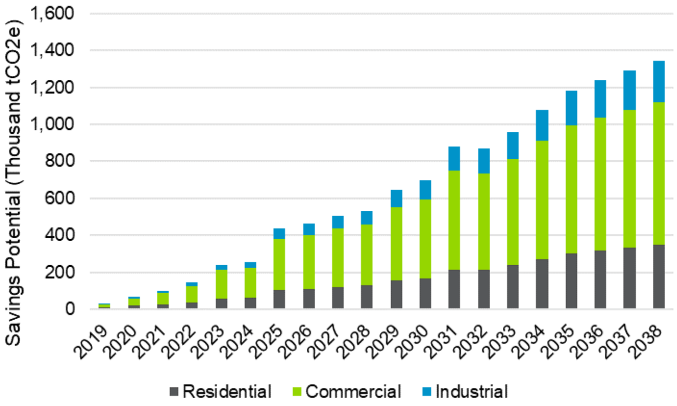
Measure Rank	Measure Name	Potential (MW)	% of Pot.
10	Improved Controls - Process Cooling	10	3%
11	Greenhouse Grow Lights	7	2%
12	Process Optimisation (Elec)	7	2%
13	Material Handling Improvements	6	2%
14	Cooling Tower Optimisation	4	1%
15	Refiner Plate Improvements	4	1%
16	Ventilation Optimisation	3	1%
17	HE Lighting	2	1%
18	VAV Conversion Project	2	0%
19	Process Heat Recovery	1	0%
20	Process Improvements	1	0%

Source: Navigant analysis

7.3.5 Emissions Reductions Results

Figure 7-16 shows the total electric energy emissions reduction potential for each sector in Scenario A. The general trend can be found to track the potential of each sector, with the drops in 2024, between 2025 and 2028, and in 2032 being due to the forecast decline in the emissions intensity (as seen in Figure 5-23 of the technical potential chapter) of electricity being greater than the growth of potential in those years.

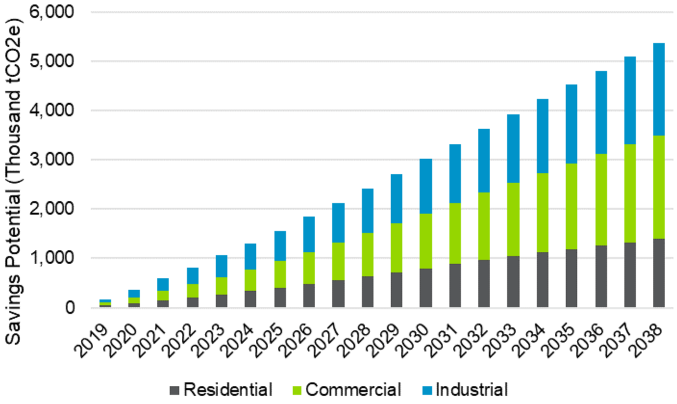
Figure 7-16. Electric Energy Emissions Reduction Potential by Sector (Thousand tCO2e) – Scenario A



Source: Navigant analysis

Figure 7-17 shows the total natural gas energy emissions savings potential for each sector in Scenario A. Given that a constant GHG emissions intensity was assumed for natural gas, the trend of abated emissions directly tracks the economic potential over time as well as the trend seen with the technical potential.

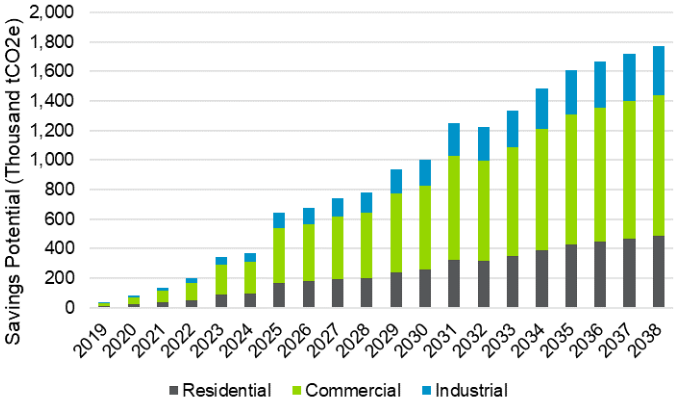
Figure 7-17. Natural Gas Energy Emissions Savings Potential by Sector (Thousand tCO2e) – Scenario A



Source: Navigant analysis

Figure 7-18 shows the total electric energy emissions reduction potential for each sector in Scenario B. The general trend can be found to track the potential of each sector, with the drops in 2024, between 2025 and 2028, and in 2032 being due to the forecast decline in the emissions intensity (as seen in Figure 5-23 of the technical potential chapter) of electricity being greater than the growth of potential in those years.

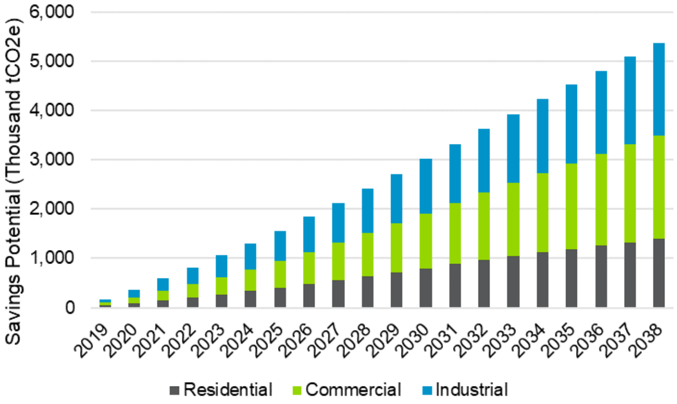
Figure 7-18. Electric Energy Emissions Reduction Potential by Sector (Thousand tCO2e) – Scenario B



Source: Navigant analysis

Figure 7-19 shows the total natural gas energy emissions savings potential for each sector in Scenario B. Given that a constant GHG emissions intensity was assumed for natural gas, the trend of abated emissions directly tracks the economic potential over time as well as the trend seen with the technical potential.

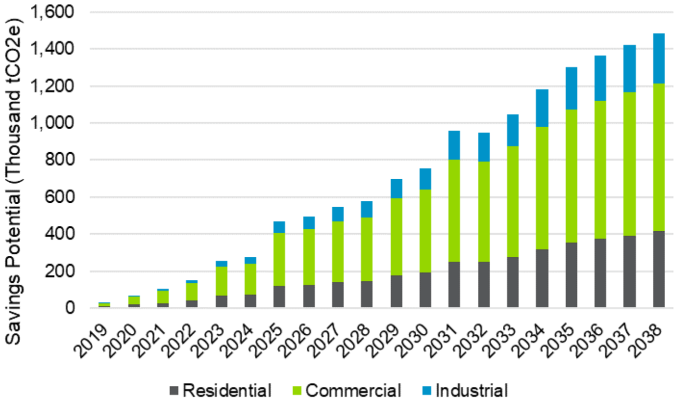
Figure 7-19. Natural Gas Energy Emissions Savings Potential by Sector (Thousand tCO2e) – Scenario B



Source: Navigant analysis

Figure 7-20 shows the total electric energy emissions reduction potential for each sector in Scenario C. The general trend can be found to track the potential of each sector, with the drops in 2024, between 2025 and 2028, and in 2032 being due to the forecast decline in the emissions intensity (as seen in Figure 5-23 of the technical potential chapter) of electricity being greater than the growth of potential in those years.

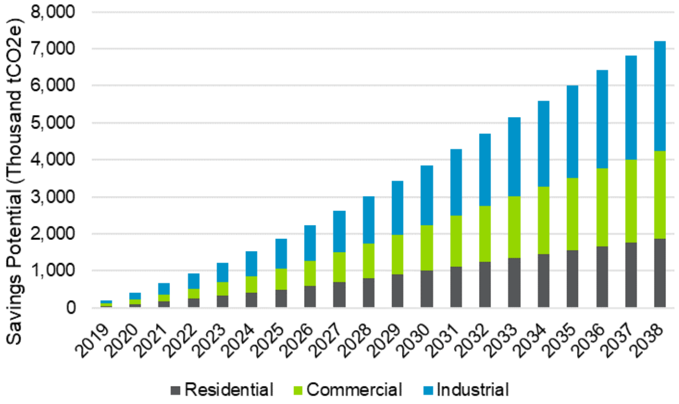
Figure 7-20. Electric Energy Emissions Reduction Potential by Sector (Thousand tCO2e) – Scenario C



Source: Navigant analysis

Figure 7-21 shows the total natural gas energy emissions savings potential for each sector in Scenario C. Given that a constant GHG emissions intensity was assumed for natural gas, the trend of abated emissions directly tracks the economic potential over time as well as the trend seen with the technical potential.

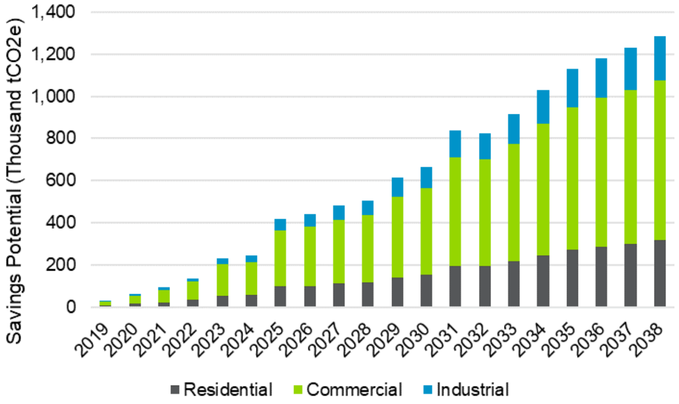
Figure 7-21. Natural Gas Energy Emissions Savings Potential by Sector (Thousand tCO2e) – Scenario C



Source: Navigant analysis

Figure 7-22 shows the total electric energy emissions reduction potential for each sector in Scenario D. The general trend can be found to track the potential of each sector, with the drops in 2024, between 2025 and 2028, and in 2032 being due to the forecast decline in the emissions intensity (as seen in Figure 5-23 of the technical potential chapter) of electricity being greater than the growth of potential in those years.

Figure 7-22. Electric Energy Emissions Reduction Potential by Sector (Thousand tCO2e) – Scenario D



Source: Navigant analysis

8. WHOLE BUILDING ANALYSIS

As described in the previous chapters of this report, achievable potential was modelled in this potential study using a bottom-up approach. This approach looks at measure-level costs and savings assumptions and considers how these measures can be implemented in different sectors as the Ontario economy grows and changes over time. This is a standard approach for achievable potential studies that has been used in jurisdictions across North America.

To understand how this bottom-up approach compares to an alternative top-down (econometric) approach to modeling energy efficiency potential, Navigant conducted a Whole Building Analysis (WBA) looking specifically at the hospitals segment. This work should be used as a learning exercise to inform future potential studies and the associated data requirements.

This chapter of the report is divided into four sections:

1. **Scope:** Describes the scope of the analysis, key objectives, and outputs.
2. **Methodology:** Provides a high level overview of Navigant's top-down (econometric) approach to estimating achievable conservation potential. This section also provides a high level overview of the data used to conduct the analyses.
3. **Results:** Presents the achievable conservation potential from the top-down (econometric) approach.
4. **Key Findings and Recommendations:** Summarises the findings and recommendations for enhancements and insights as to whether this approach is a viable alternative to the traditional bottom-up approach.

8.1 Scope

The scope of the WBA was to estimate energy efficiency potential using a top-down approach for a single segment to contrast with the bottom-up DSMSim potential. Part of this task was also to assess what data was available for analysis. Navigant selected the hospitals segment for this task because it was covered under various reporting databases, which are described later in the chapter.

The primary objective of this task was to explore an econometric approach to projecting achievable potential for electricity and natural gas, respectively, and to contrast this potential with the bottom-up model outputs, exploring and using data sources available to Navigant that cover the selected (hospitals) segment.

A secondary objective of this task was to provide a benchmark for the Technical and Economic Potential values for electricity and natural gas, respectively, output by the bottom-up model. Discussions regarding the benchmarking methodology and results are presented in Appendix G.

8.2 Methodology

This section provides a high level overview of the top-down approach Navigant used to estimate conservation potential. This section is divided into the following sub-sections:

- Data Requirements
- Data Availability and Segment Selection

- Econometric Approach to Estimate Achievable Potential
- Overview of Data

8.2.1 Data Requirements

A key requirement of any top-down approach, modelling or benchmarking, is historical data that can be used to estimate a relation between the observable outcome—in this case changes in consumption—and the factors expected to drive said outcome, such as energy efficiency-related drivers, building space, and hospital use. This relationship can then be used to make future projections.

When choosing the focus of this analysis, Navigant looked for a segment that had at least 5 years of historical data at the building level that could be used to estimate a relationship. To compare the results of the top-down approach with the bottom-up approach, Navigant looked for a segment that aligned well with one of the segments defined in this potential study (see Section 2.1.3). Navigant also looked for datasets that covered the entire province.

To isolate the impacts of energy efficiency programs, the analysis required data that could capture the aspects of programs that drive energy efficiency, such as the value of incentives paid out in any given year. In addition, the analysis needed to control for other factors that influence consumption to isolate the impacts of energy efficiency programs. These other factors included weather, occupancy rates, and other building-specific characteristics such as size, building envelope, and special equipment.

8.2.2 Data Availability and Segment Selection

The availability of historical consumption data at the building level was a key factor in determining what segments could be analyzed for this potential study. Due to time, cost, and privacy constraints, it was not feasible to request individual customer data for a particular segment for the entire province from all the electric LDCs and natural gas utilities. Hence, the analysis had to be based off publicly available data or data that could be requested from other institutions.

Under Ontario Regulation 507/18, Broader Public-Sector organisations across the entire province are required to report annual energy use and greenhouse emissions. This publicly available dataset (BPS data) provides information on annual consumption of electricity and natural gas at the building level, along with associated floor space information, from 2011 through 2016. This data includes information on municipal buildings, post-secondary educational institutions, schools, and hospitals.

Navigant considered various potential data sources (see Appendix G.1.1 for details), and after careful consideration determined that the BPS data was the best path forward given the challenges of obtaining province-wide data from other sources. In addition to having province-wide coverage, a key advantage of the BPS data was that it is not anonymized and can be easily mapped with other data sources to obtain building-specific information to control for other factors that influence consumption.

The hospital segment was selected for the analysis because it mapped well to the hospitals segment as defined for this potential study, had less variation in the building types (facilities used for hospitals and for administration), and there was some information available on individual hospitals that could be used to control for other factors that influence consumption.

8.2.3 Econometric Approach to Estimate Achievable Potential

Historical energy consumption data reflects the impacts of energy efficiency program savings. This data can be used to estimate a relationship against incentives offered by such programs that drive the adoption of more efficient technologies that result in savings. In the absence of energy efficiency programs, the historical consumption would have been higher.

A variety of methods can be used to estimate a relationship. Given the nature of the data—i.e., has time-series data for multiple subjects, also known as a panel dataset—and the need to put uncertainly bands around the estimates, a panel econometric approach was deemed to be the most appropriate. A panel econometric is a type of regression analysis used when there are multiple subjects and a time series for each subject. An econometric approach applies statistical methods to economic data to identify and quantify relationships.

Navigant developed regression models to estimate the historical impact of energy efficiency program incentives on building energy intensity by controlling for other factors such as weather, retail rates, hospital usage, and building-specific characteristics. The historical relationship was then used to estimate conservation potential from 2019 through 2038 based on the forecast incentives used in the bottom-up model for Scenarios A and B (see Section 7.2.2.2). See Appendix G.1.2 for additional details.

Navigant developed basic and enhanced regression models for this analysis to explore the importance of model specification[69] and data availability (see Figure 8-1). The basic model related energy intensity to building characteristics that do not change over time: retail rates for energy, weather, annual heating, and cooling degree hours, and cumulative program incentives. The enhanced model included an additional variable that accounts for hospital usage: the total annual emergency wait time for each building.

Figure 8-1. Basic and Enhanced Model Overview

Source: Navigant analysis

8.2.4 Overview of Data

This section provides an overview of the data used in the analyses.

8.2.4.1 Broader Public Sector (BPS) Data Overview

Under Ontario Regulation 507/18, Broader Public-Sector (BPS) organisations, which includes hospitals, are required to report annual energy use and greenhouse emissions. This data is publicly available[70] and contains a list of hospital buildings along with associated floor space and annual electric and natural gas consumption for each year from 2011 through 2016. Navigant used this data to calculate the annual energy intensity for each building.

The BPS data contained data for 448 buildings representing 151 hospitals, which are shown in Figure 8-2. Most of the hospitals were located in the Toronto and Southwest zones, with 116 and 114 buildings,

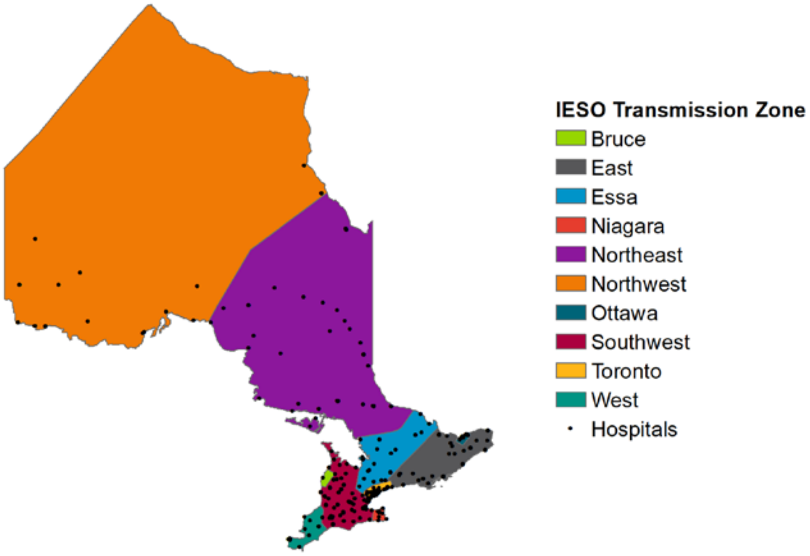
---

[69] Model specification refers to the variables included in the regression analysis. It is important to explore which variables are adding value to the model which cannot be known with certainly in advance and hence different model specifications were tested as part of the due diligence process.

[70] See https://www.ontario.ca/data/energy-use-and-greenhouse-gas-emissions-broader-public-sector

respectively. Navigant conducted analyses to identify outlier observations and excluded those from the analyses, see Appendix G.1.4 for additional detail.

Figure 8-2. Geographic Dispersion of Hospitals in the BPS Dataset



Source: Navigant analysis

8.2.4.2 Program Data Overview

IESO and the natural gas utilities provided data on historical energy efficiency program incentives offered to the commercial sector from 2011 to 2016. The forecast incentives are the same values used in the bottom-up model to ensure an appropriate comparison. Figure 8-3 in Section 8.3 compares the historical and forecast incentives and puts them into context with the results.

8.2.4.3 Weather Data Overview

Navigant obtained historical hourly weather data for 2011 through 2016 from Environment and Climate Change Canada[71] for representative weather stations throughout Ontario. To select the weather stations, Navigant determined the closest weather station to each hospital in the BPS dataset and used those stations to create representative weather profiles for each IESO zone. Further details on the preparation of weather variables for this analysis are provided in Appendix G.1.

8.2.4.4 Canadian Institute for Health Information (CIHI) Data Overview

The Canadian Institute for Health Information (CIHI) organisation[72] collects and provides data and information for all healthcare organisations in Canada, including hospitals in Ontario. Navigant obtained data from CIHI covering 2012 through 2016; the data contained a variety of indicators for each hospital,

---

[71] See http://climate.weather.gc.ca/index_e.html

[72] See https://www.cihi.ca

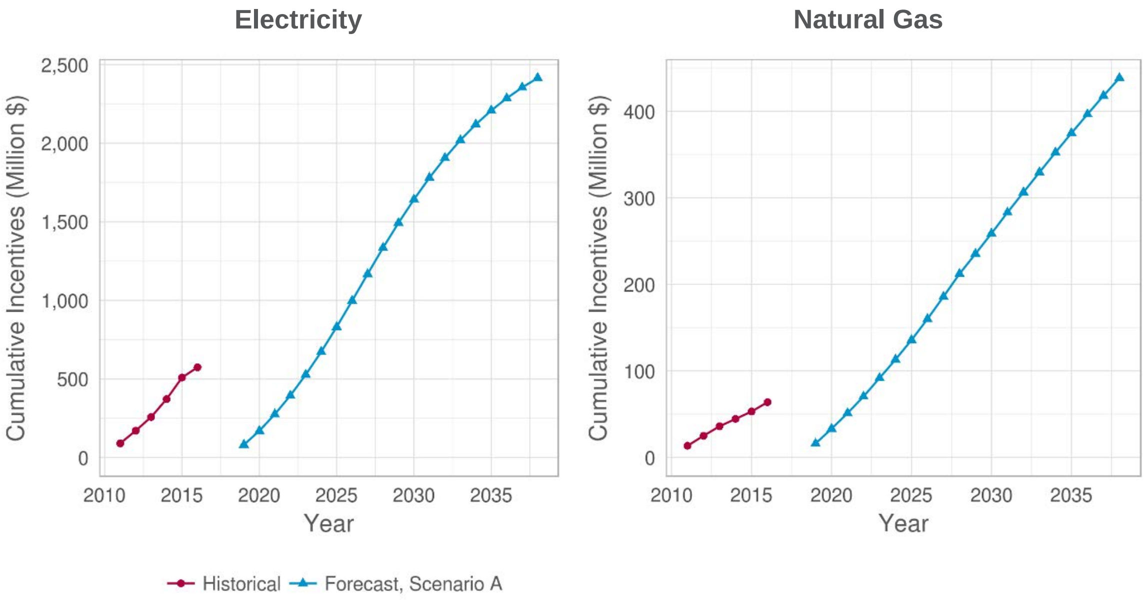
including administration costs, number of patients readmitted, average cost of stay, and total emergency wait time.

8.3 Results

As described in Section 8.2.3, Navigant estimated the impact of historical incentives on energy intensity. The achievable potential was forecast by projecting the impact of cumulative incentives on energy intensity over the 2019-2038 period.

Figure 8-3 shows the cumulative historical (2011-2016) and forecast (2019-2038) incentives for the commercial sector, both for electricity and natural gas. In this chart, incentives are cumulative from the first year data is available: 2011 for historical incentives and 2019 for forecast incentives. This construction ensured that the forecast potential is relative to the base year (i.e., 2018) to ensure consistency with the bottom-up model and that it does not include any reductions in energy intensity due to incentives observed in the historical data from 2011 to 2016.

Figure 8-3. Cumulative Commercial Sector Historical and Forecast Incentives – 2019-2038



Incentives are cumulative relative to the first year for which data is available: 2011 and 2019 for historical and forecast.
Source: Navigant analysis

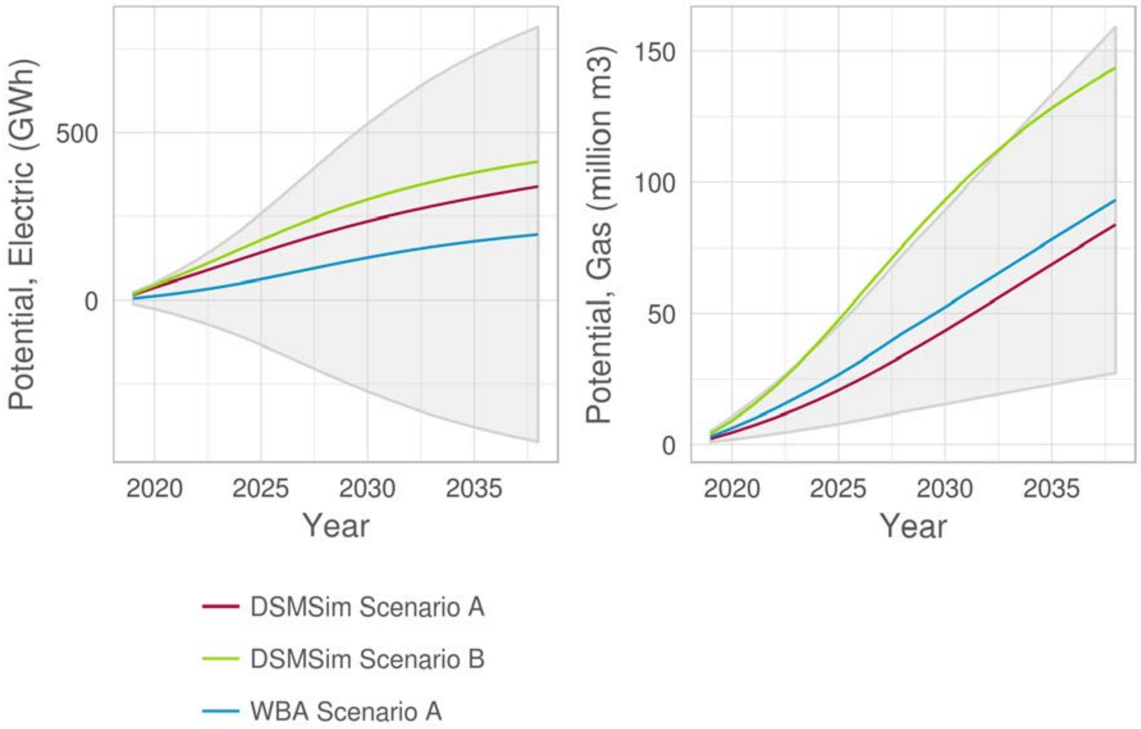
As described in Section 8.2.3, Navigant investigated a basic and an enhanced model to illustrate the importance of model specification and data availability. The basic model related energy intensity to building characteristics that do not change over time: retail rates for energy; weather, specifically annual heating and cooling degree hours; and cumulative incentives.

Figure 8-4 shows the estimated achievable conservation potential from the basic model for both electricity and natural gas from 2019 through 2038, compared to the potential savings identified in Scenarios A and B. The estimates of the basic model are directionally aligned with the bottom-up model's Scenario A outputs, but they are different in magnitude. In 2038, the estimated electric and natural gas potentials were 30% and 25% lower than the bottom-up model's respective Scenario A values. The uncertainty band (filled gray area) of the estimated conservation potential is very wide, which can be attributed to the limited sample of data, 5 years of annual historical data available for 388 buildings.[73]

The basic model attributed all non-weather-related changes in building energy intensity to energy efficiency programs. Importantly, this model did not capture other factors that may influence energy intensity—most notably the level of activity in a hospital. This may change over time; for example, a hospital that is located in a zone with significant population growth may become busier over time as more patients seek treatment.

Based on the data available, the enhanced model accounted for hospital usage by incorporating an additional variable: the total annual emergency wait time for each building, which was sourced from CIHI. Since the available CIHI data began in 2012, 2011 was excluded from the estimation.

Figure 8-4. Basic Model Forecast Conservation Potential – 2019-2038



The filled gray band represents the absolute precision of the forecast potential (90% confidence interval).

Source: Navigant analysis

Figure 8-5 shows the achievable conservation potential for 2019-2038, estimated using the enhanced model. The uncertainty bands for these estimates are much larger than those associated with the basic model, which reflects the exclusion of 2011 data in the estimation and the variability of the CIHI data itself. Nevertheless, the enhanced model resulted in forecast conservation potential that is more consistent with the bottom-up model's Scenario A potential estimates.

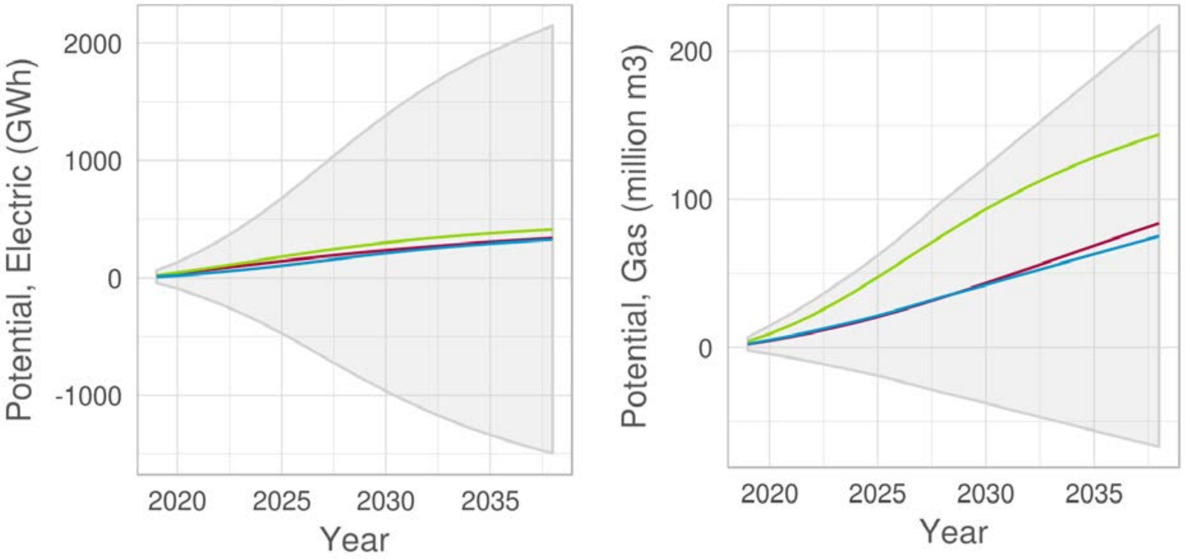
In 2038, the estimated electric and natural gas potentials were 17% higher and 1% lower than the bottom-up model's comparable Scenario A values. For electricity, the enhanced model projected a potential that is lower than the bottom-up model's prediction in early years but converges with the model's prediction in

---

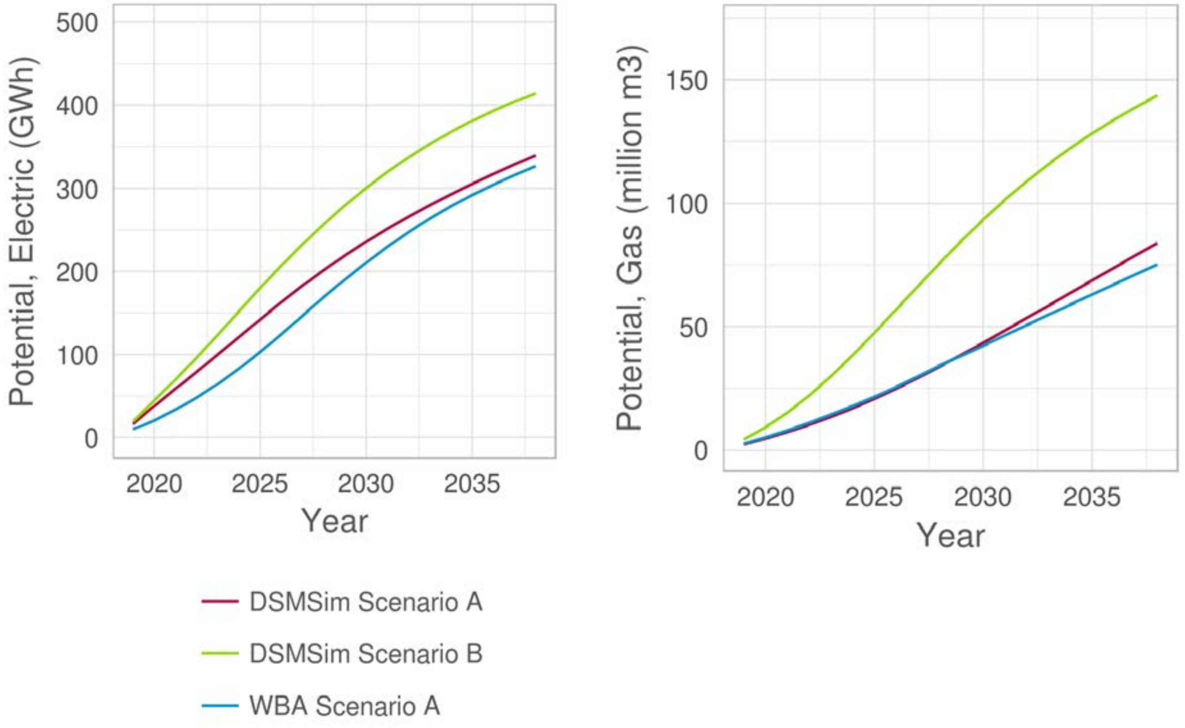
[73] The wide confidence bands are a factor of the volume of available data as well as the magnitude of the impacts being estimated / forecast. Five years of annual data is not a lot for an econometric forecast.

later years. For natural gas, the enhanced model projected a potential that is consistent with the Scenario A bottom-up model prediction throughout the analysis period.

Figure 8-5. Enhanced Model Forecast Conservation Potential – 2019-2038



Without Confidence Interval



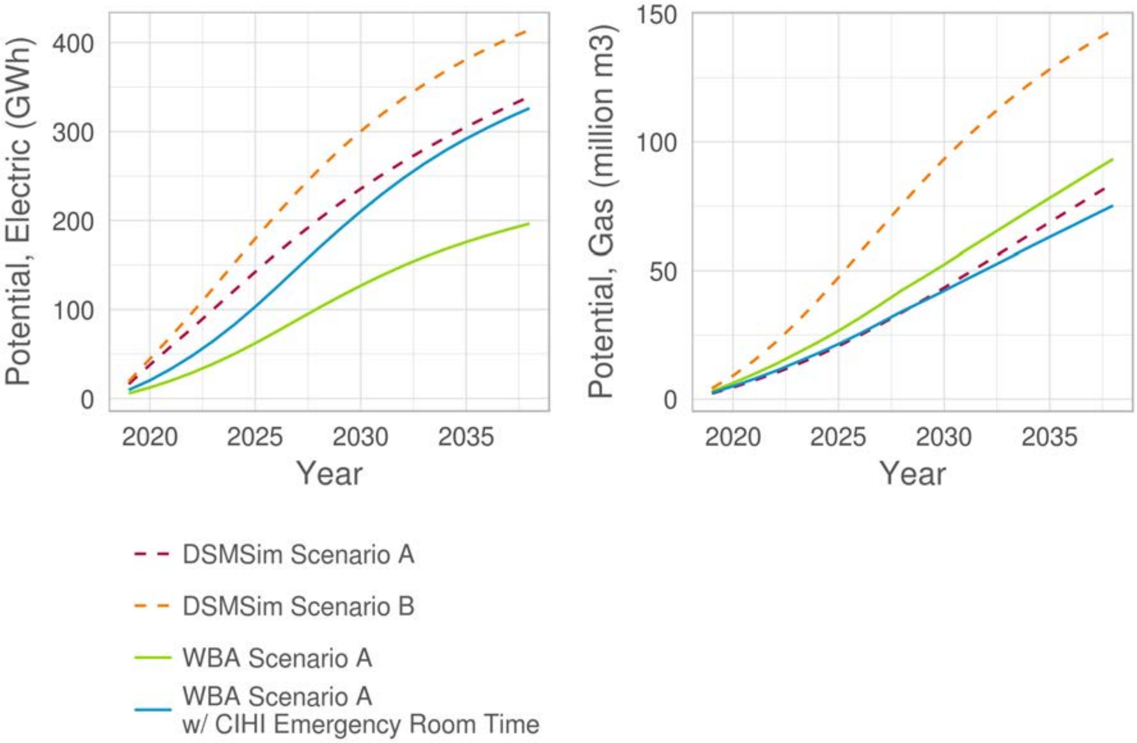
The filled gray band represents the absolute precision of the forecast potential (90% confidence interval).

Due to the low absolute precision of this model, results were plotted with and without the 90% confidence interval for clarity.

Source: Navigant analysis

Comparing the basic and enhanced regression models revealed the sensitivity of forecast conservation potentials to model specification as well as data availability. As shown in Figure 8-6, the addition of one variable and associated loss of data available for estimation led to a large change in the forecast potential and increase in the already significant uncertainty shown in the basic model. This sensitivity suggests that caution should be used when interpreting the current results of the whole building analysis.

Figure 8-6. Comparison of Basic and Enhanced Models – 2018-2038



Source: Navigant analysis

8.4 Key Findings and Recommendations

The top-down econometric approach results were generally consistent with the bottom-up modelling conducted as part of the core tasks of the 2019 potential study and described in Chapters 0-7 of this report.

This analysis also provided insights regarding available data that can be used for a top-down approach as well as an econometric approach that could be leveraged as a base and further refined in future analysis.

The feasibility of expanding the econometric approach to estimate conservation potential in other sectors is ultimately dependent on the quantity and quality of available data. While Navigant explored a number of public and proprietary datasets for this analysis as described in Appendix G.1, the BPS dataset was the only province-wide dataset that Navigant could easily combine with other data sources and met the criteria in Section 8.2.1.

Future studies could consider the possibility of leveraging energy consumption data on schools, post-secondary education institutions, and municipal buildings from the BPS dataset in conjunction with other appropriate data sources for those segments, as was done with the CIHI data for hospitals.

Under the Reporting of Energy Consumption and Water Use regulation, large commercial building owners will be required to report their building's energy and water use once a year to the Ministry of Energy, Northern Development and Mines (ENDM) and could serve as a potential data source for future studies. This became effective July 1, 2019 for buildings 100,000 square feet or more and will be effective July 1, 2020 for buildings 50,000 square feet or more. As with the BPS dataset, it will take time to populate as well as to identify and resolve issues (inconsistencies in interpretation, errors in data entry, etc.) as they arise.

The WBA does not provide insights into specific measure or end use potential because it is a top-down approach. The measure/end use-specific insights from the bottom-up approach provide useful insights, particularly for residential and some commercial programs that tend to be more streamlined, prescriptive, and targeted at specific technologies. It also helps CDM and DSM program administrators consider and understand the effects of future codes and standards changes and natural conservation that are more difficult to explicitly model in a top-down approach.

As CDM/DSM programs continue to incorporate more pay-for-performance and joint electricity and natural gas delivery models, this may become less of an issue. In the near term, prescriptive and technology-specific programs provide low cost energy savings that are more straightforward to administer, evaluate, and implement and that are supported by measure-level potential analysis.

In the WBA, Navigant forecast a conservation potential that was similar to the bottom-up model's Scenario A, an expected result as the WBA was based on a relationship estimated using historical data, and Scenario A assumptions (of the various scenarios) most closely resemble historical program actuals. However, this has two important caveats. First, the relatively few years of historical data available resulted in low precision and, therefore, wide uncertainty bands. Moreover, the analysis demonstrated the sensitivity of results to model specification; adding a single variable resulted in a much more consistent forecast with the bottom-up model's Scenario A.

Additional and more complete data could address these issues and support a more comprehensive analysis. The additional data would likely improve the precision of the WBA top-down potential estimates, but investigations will still be required to explore the sensitivity of the results to the model specifications. Some examples that would improve these modelling efforts include the following:

- Collecting data on building-specific historical incentives from the IESO and natural gas utilities and matching this to historical consumption data at the building level.
- Collecting and incorporating information on the time that the energy efficiency changes took effect and which ones were undertaken with the aid of program incentives.
- Collecting additional years of hospital-specific historical data, including energy consumption as well as indicator variables from various sources such as CIHI. More granular consumption information (e.g., hourly) would allow for more sophisticated model specifications.

9. SENSITIVITY ANALYSIS

This section describes the sensitivity analysis, which aimed to understand how variations in key model parameters affect achievable potential results. The section begins by explaining Navigant's approach to performing the sensitivity analysis. It then presents the results of the sensitivity analysis.

9.1 Scope

The goal of the sensitivity analysis was to identify which inputs and assumptions the natural gas and electric energy potential estimates were most sensitive to. Specifically, when varying the selected inputs and assumptions, the goal was to understand how much savings potential estimates varied for each potential type (technical, economic, achievable), sector, year and fuel. The methodology section discusses the two important characteristics pertaining to the sensitivity analysis:

1. **Sensitivity Parameters:** The sensitivity parameters are the model parameters that are varied in the sensitivity analysis to assess the sensitivity of output results to these parameters.
2. **Sensitivity Bounds:** The sensitivity bounds define the degree to which the sensitivity parameters are varied in the sensitivity analysis.

In addition to generating the sensitivity results, additional deliverables included summarising the methodology and results in the final report.

9.2 Methodology

The sensitivity analysis tested parameters that were identified as having a high impact on savings potential estimates as well as those with high uncertainty. This was carried out by first calculating achievable potential that resulted from running the model using unaltered parameters. Next, a single parameter was selected and adjusted by both increasing and decreasing its values by 25%, holding all other parameters constant in this achievable scenario. Upper and lower bounds on the potential were then calculated based on increasing and decreasing the parameter. These bounds informed the extents to which adjusting a given parameter could impact potential. This process was then repeated for each of the selected parameters.

9.2.1 Sensitivity Parameters

The following is a list of the parameters selected for the sensitivity analysis, a brief definition, and the reasoning behind their selection:

- **Unit Energy Savings:** The amount of energy a single unit of a measure saves per year (e.g., kWh/light bulb/year). This was selected to indicate the impact the heating degree days and equivalent full load hours assumptions[74] have on climate-sensitive measures, and the impact codes and standards have on all measures.

---

[74] The weather factors related to the heating equipment's run time and power, directly impacting the volume of energy savings.

- **Forecasted Energy Consumption:** The anticipated future demand for energy consumption. Analyzing this addressed the uncertainty surrounding the assumptions embedded in the forecasts of building stock, population growth, etc.
- **Initial Awareness:** The percentage of the population aware and able to adopt a measure. This parameter was selected to address the uncertainty around the current state of Ontario’s market and the inputs provided by the Delphi Panel of experts.
- **Incremental Measure Cost:** The difference in cost between the efficient and baseline measure. Analyzing this addressed the uncertainty in the measure cost assumptions.
- **Retail Rates:** The cost of energy to the customer. This was selected because retail rates affect customer decision-making, and it was valuable to understand how sensitive customers were to varying retail rates.
- **Measure Densities:** Number of units per scaling basis (e.g., light bulbs per household). This addressed the uncertainty of embedded assumptions and showed if there was a business case for additional data collection.
- **Benefit/Cost Test Threshold:** Measures’ benefits divided by their costs must be greater than or equal to the benefit/cost threshold to be considered cost-effective. Varying this threshold detailed the impact of using a TRC-plus threshold other than 1 (and implicitly, mimicked a change in avoided costs).
- **Payback Acceptance:** The willingness of a customer to adopt a measure given the time it takes to recover the cost of purchasing the measure. This parameter was selected to address the uncertainty around the current state of Ontario’s market and the inputs provided by the Delphi Panel of experts.
- **Efficient Saturation:** The percentage of existing measures that are of the efficient type (as opposed to the baseline/code measure). Varying this showed if there was a business case to support collecting more data around the current state of how much of each measure is in the field.
- **Re-Participation Rate (Persistence):** When measures reach the end of the useful life, this is the rate at which they are replaced by the same efficient technology (as opposed to the baseline/code technology). This was selected to simulate what savings would occur if the market was not completely transformed once participating in the program (i.e., current assumption is 100% re-participation).

9.2.2 Sensitivity Bounds

The amount by which the sensitivity parameters were adjusted is known as the sensitivity bounds. In this potential study, the bounds were produced by multiplying the original values by +/- 25%, resulting in sensitivity bounds of 0.75X to 1.25X, where X is the sensitivity parameter.

These bounds were selected because these values were believed to encapsulate a reasonable degree of uncertainty possible for any of the selected parameters. The same bounds were used for all parameters to ensure consistency and comparability of results across parameters.

9.3 Results

This section provides the sensitivity analysis results broken down by potential type and sector. This includes natural gas and electric energy results.[75] The results displayed are shown as percent differences from the achievable potential that resulted from running the model using unaltered parameters. Specifically, the 0% line represents the unadjusted potential while the blue and red bars denote the change in potential resulting from varying the sensitivity parameters.

9.3.1 Technical Potential Results

The following section summarises the impact of the following parameters on technical potential:

- Unit energy savings
- Forecasted energy sales
- Measure densities
- Efficient saturation

The remaining parameters, including re-participation rate, payback acceptance, retail rates, B/C test threshold, incremental cost and initial awareness, did not affect technical potential results.

9.3.1.1 Portfolio Results

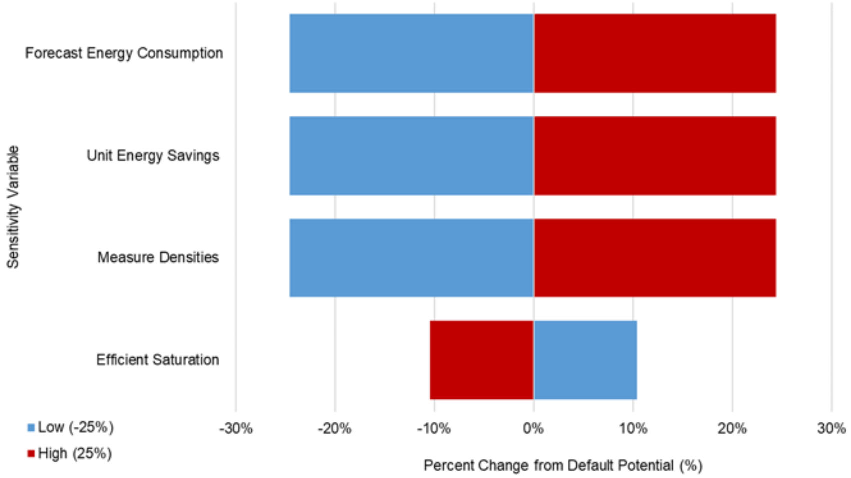
Figure 9-1 shows the total electric energy technical potential in 2038 for the portfolio resulting from the sensitivity analysis. Forecasted energy sales, unit energy savings, and measure densities are direct scalars of potential. At the technical potential level where cost-effectiveness and customer adoption were not considered, each percent change of the input for each of these parameters resulted in approximately an equal percent change in the potential.

Efficient saturation had a lower impact on technical potential and was also inversely proportional to the percent change of the input (i.e., as efficient saturation increased the potential decreased). Because efficient saturation represented how much of the current market was saturated with the efficient technologies, as this parameter increased, the market potential for energy efficiency measures and associated energy savings potential decreased.

---

[75] All results shown are presented after considering the impacts of measure stacking and impacts on energy unit potential related to Scenario C.

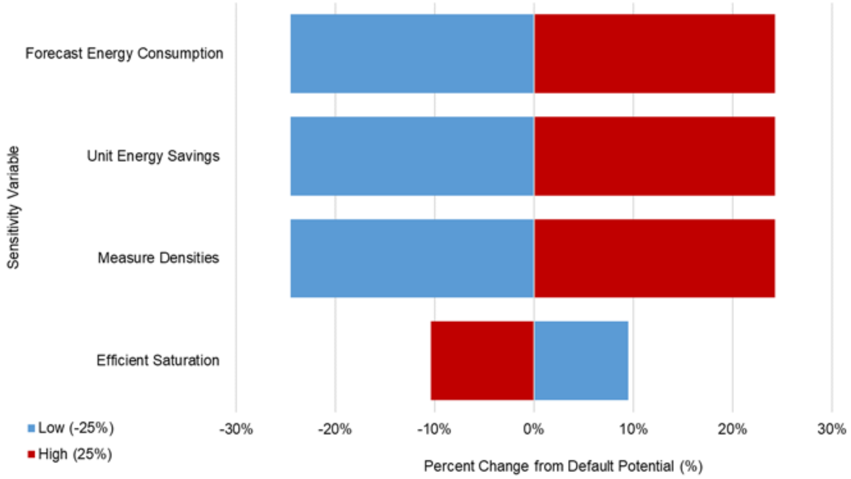
Figure 9-1. Electric Energy Technical Potential for the Portfolio in 2038 (%)



Source: Navigant analysis

Figure 9-2 shows the total natural gas energy technical savings in 2038 for the portfolio resulting from the sensitivity analysis. Similar to the electric energy results, the forecasted energy sales, unit energy savings, and measure densities each had the same significant impact on potential because they were direct scalars of potential. In addition, the efficient saturation had a relatively lower impact and was also inversely proportional to the percent change of the input.

Figure 9-2. Natural Gas Energy Technical Potential for the Portfolio in 2038 (%)

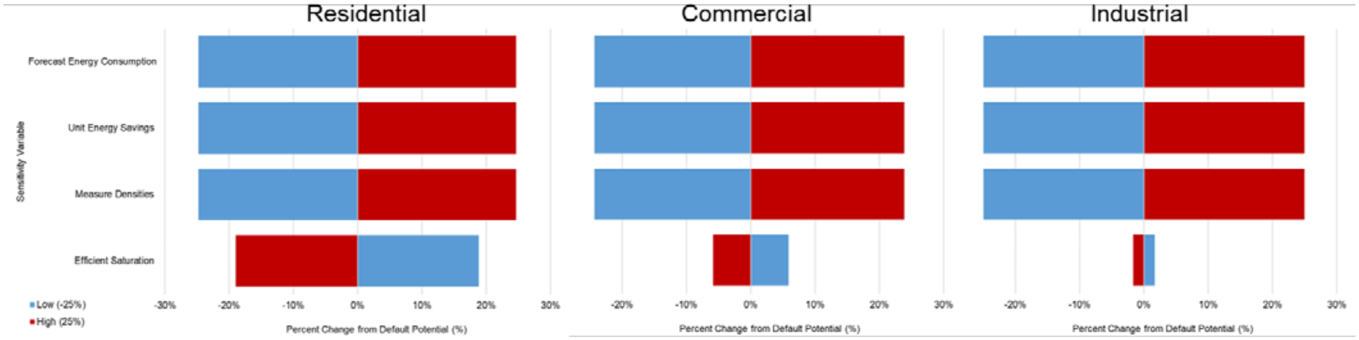


Source: Navigant analysis

9.3.1.2 Sector Results

Figure 9-3 shows the total electric energy technical potential by sector in 2038 resulting from the sensitivity analysis. As seen with the portfolio-level results, varying the forecasted energy sales, unit energy savings, and measure densities parameters had a significant impact on potential, showing that each percent change of the input values resulted in approximately an equal percent change in the potential. The efficient saturation for the residential sector had a more significant impact on potential than that seen at the portfolio level but had a less significant impact on potential for the commercial and industrial sectors than seen at the portfolio level.

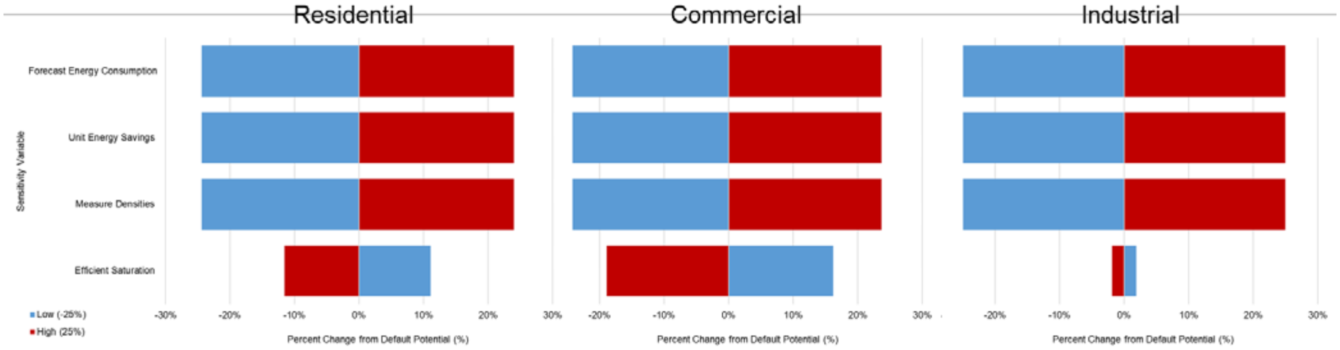
Figure 9-3. Electric Energy Technical Potential by Sector in 2038 (%)



Source: Navigant analysis

Figure 9-4 shows the total natural gas energy technical savings in 2038 for all sectors resulting from the sensitivity analysis. Similar to the electric energy results, the forecasted energy sales, unit energy savings, and measure densities each had the same significant impact on potential because they were direct scalars of potential. In addition, the efficient saturation had a relatively lower impact and is also inversely proportional to the percent change of the input for all three sectors.

Figure 9-4. Natural Gas Energy Technical Potential in 2038 (%)



Source: Navigant analysis

9.3.2 Economic Potential Results

For all figures in the economic potential section, there appears to be no change in results based on varying the following parameters:

- Re-participation rate (persistence)
- Payback acceptance
- Retail rates
- Initial awareness

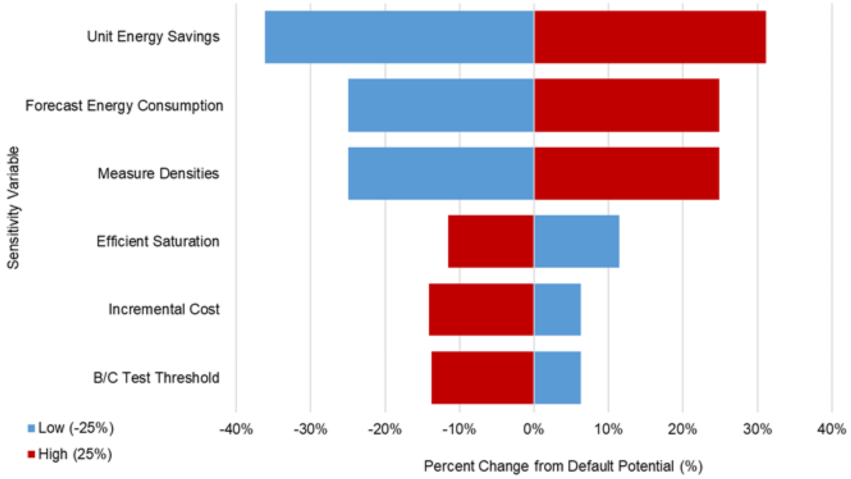
Re-participation did not impact economic potential because economic potential is presented as a snapshot in time as if all eligible technology was replaced in a given year, which prevents measures from needing replacement. For the remaining three parameters, the sensitivity analysis resulted in no change to the potential because each of these parameters only began to impact potential in the achievable stage.

9.3.2.1 Portfolio Results

Figure 9-5 shows the total electric energy economic potential in 2038 for the portfolio resulting from the sensitivity analysis. At the economic potential level, the unit energy savings had the highest impact on potential of any parameter because it is a direct scalar of energy savings and benefits considered in the TRC-plus cost test, so each measure contributed more savings and more measures that pass the cost-effectiveness test.

Similar to the efficient saturation, the incremental cost and B/C test threshold parameters had a lower impact and were also inversely proportional to the percent change of the input. Specifically, as the incremental cost and B/C test threshold increased, the potential decreased. For incremental cost, this was because as costs increased, measures became less cost-effective. The same is true for the B/C test threshold. As the threshold increased, less measures were able to pass the threshold and were deemed not cost-effective and excluded from economic potential.

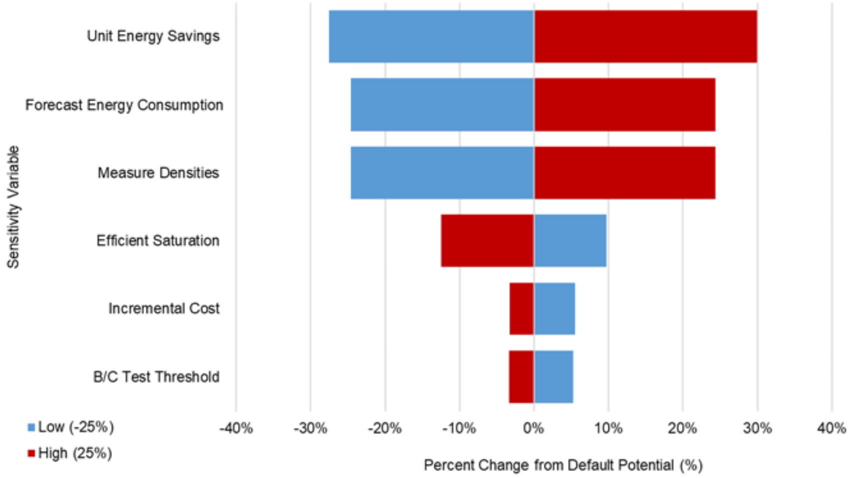
Figure 9-5. Electric Energy Economic Potential for the Portfolio in 2038 (%)



Source: Navigant analysis

Figure 9-6 shows the total natural gas energy economic savings in 2038 for the portfolio resulting from the sensitivity analysis. Similar to the electric energy results, the unit energy savings had the greatest impact on potential because it was a direct scalar of potential and benefits. In addition, the incremental cost and B/C test threshold had relatively lower impacts and were also inversely proportional to the percent change of the input.

Figure 9-6. Natural Gas Energy Economic Potential for the Portfolio in 2038 (%)

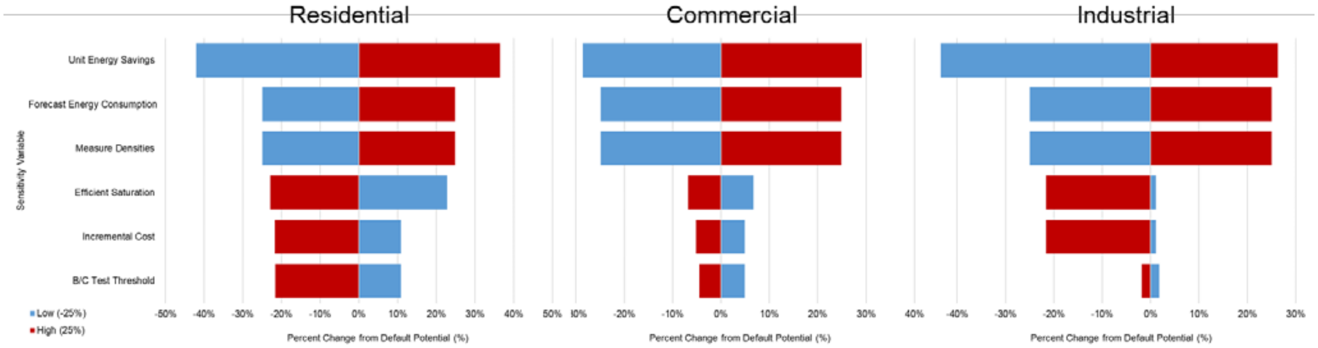


Source: Navigant analysis

9.3.2.2 Sector Results

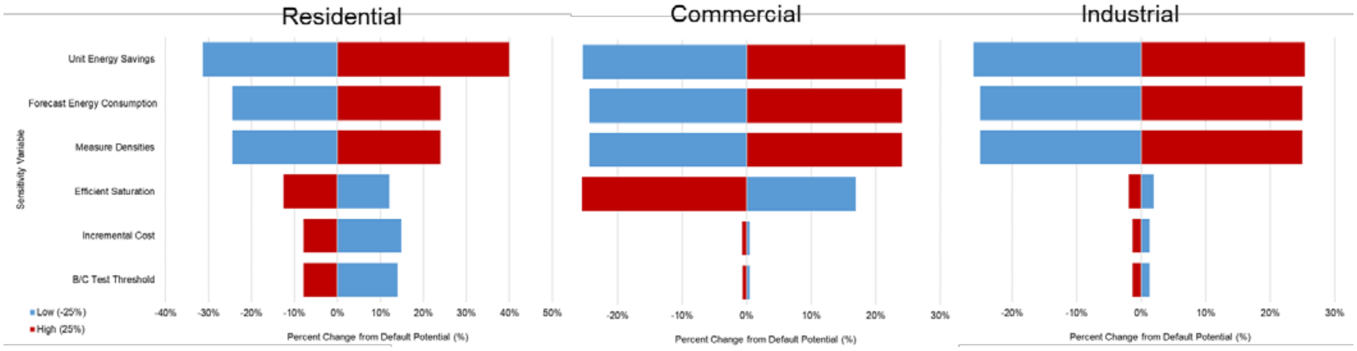
Figure 9-7 shows the total electric energy economic potential by sector in 2038 resulting from the sensitivity analysis. As seen with the portfolio-level results, varying the unit energy savings had a significant impact on potential. The efficient saturation, incremental cost, and B/C test threshold for the residential sector had a more significant impact on potential than that seen at the portfolio level. The efficient saturation, incremental cost, and B/C test threshold for the commercial sector had less of an impact on potential than that seen at the portfolio level. The efficient saturation had a much lower impact on potential for the industrial sector than that seen at the portfolio level. The incremental cost and B/C test threshold for the industrial sector had a more significant impact on potential than that seen at the portfolio level.

Figure 9-7. Electric Energy Economic Potential by Sector in 2038 (%)



Source: Navigant analysis

Figure 9-8. Natural Gas Energy Economic Potential by Sector in 2038 (%)



Source: Navigant analysis

Figure 9-8 shows the total natural gas energy economic savings in 2038 all sectors resulting from the sensitivity analysis. Similar to the electric energy results, the unit energy savings had the greatest impact on potential for all three sectors because it was a direct scalar of potential and benefits. In addition, the incremental cost and B/C test threshold had relatively lower impacts and were also inversely proportional to the percent change of the input for all three sectors.

9.3.3 Achievable Potential Results

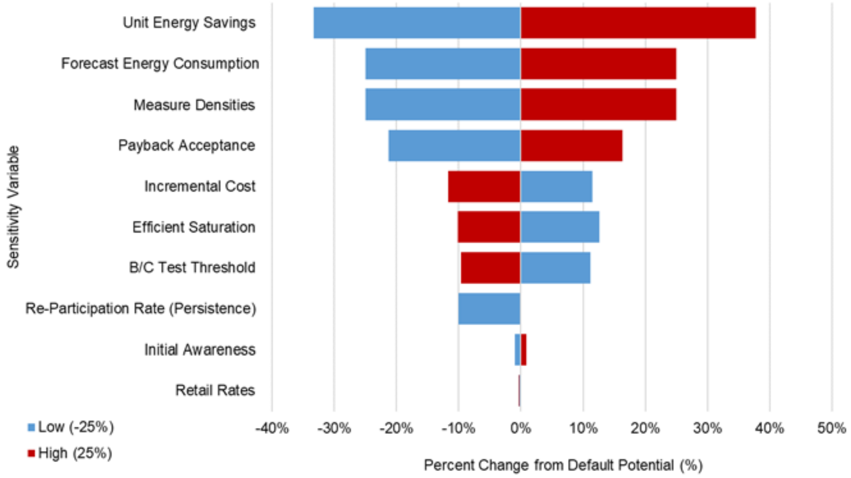
9.3.3.1 Portfolio Results

Figure 9-9 shows the total electric energy achievable savings potential in 2038 for the portfolio resulting from the sensitivity analysis. At the achievable potential level, the unit energy savings parameter continued to have the highest impact on potential of any parameter because it was a direct scalar of both energy savings and benefits.

The ranking of the parameters at the economic level remained the same, except that incremental cost overtook the efficient saturation parameter. This is because, in addition to driving the cost-effectiveness of measures, incremental costs were used to determine their payback periods, which influences the customers' willingness to adopt.

Of the parameters that impact achievable potential analysis (i.e., payback acceptance, initial awareness, retail rates, re-participation rate), payback acceptance was the most sensitive parameter. This was because payback acceptance dictated the percentage of customers that were willing to adopt a measure. Given that the re-participation rate was initially assumed to be 100%, there were only sensitivity results for when this parameter was decreased. Initial awareness had a relatively lower impact. This figure shows the results in 2038, the end of the potential reference forecast period, where diffusion was dictated by word of mouth and marketing. Initial awareness typically had a much larger impact near the beginning of a study, with marketing and word of mouth having smaller impacts, and vice versa as time went on. Finally, retail rates had a limited impact on electric energy achievable potential because of the low avoided costs of electricity. The low avoided costs necessitated that for measures to be cost-effective, the incremental costs had to be low. Given that only cost-effective measures were considered in achievable potential, the measures were already extremely attractive to customers and their decision was minimally impacted by a change in the retail rates.

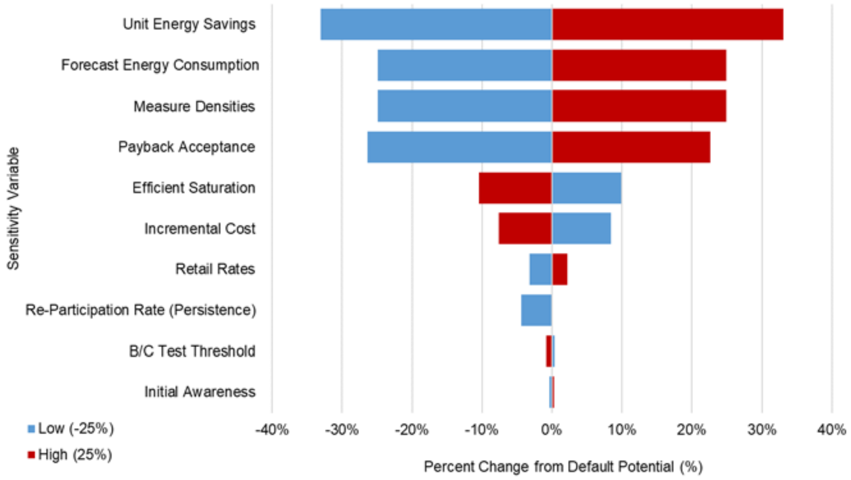
Figure 9-9. Electric Energy Achievable Savings Potential for the Portfolio in 2038 (%)



Source: Navigant analysis

Figure 9-10 shows the total natural gas energy achievable savings in 2038 for the portfolio resulting from the sensitivity analysis. Similar to the electric energy results, the unit energy savings had the greatest impact on potential because it was a direct scalar of potential and benefits. In addition, the retail rates had a greater impact with respect to natural gas measures because the avoided costs were more comparable to the retail rates. This means that although the measures passed the economic screen, they were not as immediately attractive to the customer as electric measures; thus, adjusting the retail rates impacts the customers' willingness to adopt the measure.

Figure 9-10. Natural Gas Energy Achievable Savings Potential for the Portfolio in 2038 (%)

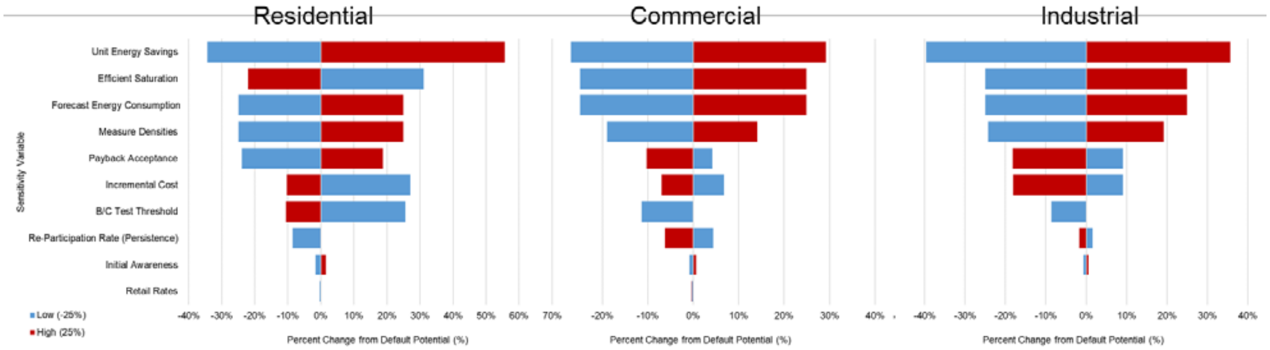


Source: Navigant analysis

9.3.3.2 Sector Results

Figure 9-11 shows the total electric energy achievable savings potential in 2038 for all sectors resulting from the sensitivity analysis. As seen with the portfolio-level results, varying the unit energy savings had a significant impact on potential. Of the achievable potential-specific parameters, payback acceptance had the greatest impact, with retail rates and initial awareness having the smallest impact on achievable potential.

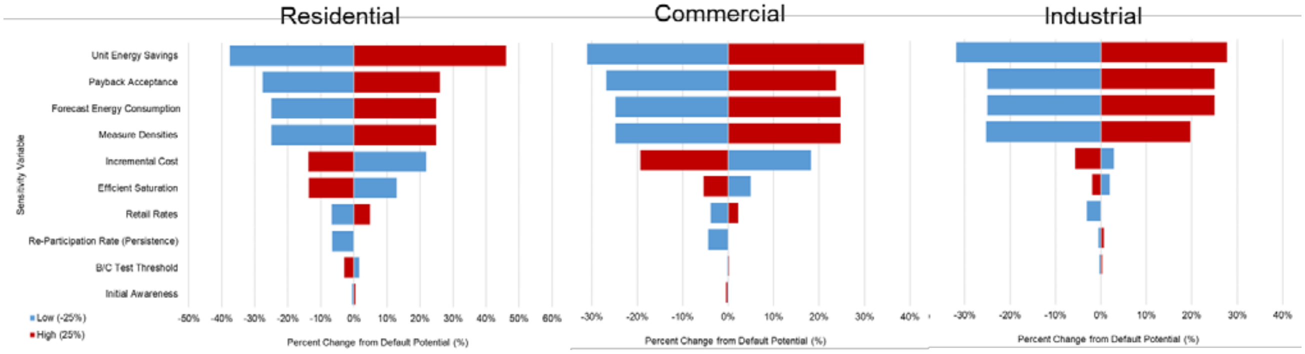
Figure 9-11. Electric Energy Achievable Savings Potential by Sector in 2038 (%)



Source: Navigant analysis

Figure 9-12 shows the total natural gas energy achievable savings in 2038 for all sectors resulting from the sensitivity analysis. Similar to the electric energy results, the unit energy savings had the greatest impact on potential because it was a direct scalar of potential and benefits. In addition, the payback acceptance parameter drove the greatest impact on potential of all of the achievable potential-specific parameters. However, retail rates had a greater impact on potential for natural gas than it did for electric energy.

Figure 9-12. Natural Gas Energy Achievable Savings Potential by Sector in 2038 (%)



Source: Navigant analysis

10. FINDINGS AND RECOMMENDATIONS

This chapter provides Navigant's key study findings and recommendations to be considered for the development of future integrated potential studies.

This chapter is divided into two sections: Findings and Recommendations. The Findings section highlights Navigant's observations of the dynamics underlying the estimated potential and of the results themselves; it provides key insights about the study inputs and results. The Recommendations section identifies a set of recommendations that should be considered by the IESO and OEB when planning the development of future potential studies.

10.1 Findings

This section of this chapter is divided into two sub-sections:

- **Provincial Findings:** This sub-section focuses on findings unique to the context, timing, and location of this study (e.g., the dynamics of forecast electric avoided costs and retail rates), as well as specifics regarding the implications of the distribution of forecast potential.
- **Sector-Level Findings:** This sub-section focuses on findings related to the projected potential for specific sectors, identifying trends in projected potential, and the reference forecast that may be of interest to program administrators. This section also highlights sector-specific findings related to the primary research undertaken as part of the Delphi-style survey to identify sector-specific measure adoption traits.

10.1.1 Provincial Findings

The following are important findings and observations based on the unique timing and structure of this study.

10.1.1.1 Potential Findings

The key finding of this study is that there remains a significant amount of cost-effective energy efficiency potential across both fuels (electricity and natural gas) in both the near and longer-term. In examining a high-level summary of projected potential, a few key trends are clearly identifiable, the most important of which is that, relative to consumption, the commercial sector has the most significant share of remaining achievable potential.

Electricity

Table 10-1. Provincial Electricity Results[76]

Year	2023	Distribution of Forecast Consumption Across Sectors	Distribution of Potential Across Sectors	2038	Distribution of Forecast Consumption Across Sectors	Distribution of Potential Across Sectors
Sector	Commercial	36%	62%	Commercial	37%	54%
	Residential	34%	26%	Residential	34%	28%
	Industrial	29%	12%	Industrial	29%	18%

Source: Navigant analysis

For electricity, savings potential is dominated by the commercial sector. Commercial sector electricity potential in 2038 accounts for more than half of the total potential, despite commercial consumption only being forecast to be 37% of total. Likewise, industrial potential – 18% of the total – is quite low compared to projected consumption (28% of total).

This implies an outsized opportunity for energy efficiency potential in the commercial sector. There are two major drivers of this result: the very high potential for lighting energy efficiency, and the very high potential for whole building (particularly ventilation-related).

Lighting is a much bigger opportunity in the commercial than in the residential sector in large part because, unlike the residential sector, commercial sector lighting is not forecast to be subject to a very high level of natural conservation. The small amount of forecast lighting natural conservation in the commercial sector means there is a significantly larger opportunity for energy efficiency in the commercial than in the residential sector.

The second driver contributing to the commercial sector delivering the highest proportion of savings potential is the significant opportunity in whole building systems, particularly ventilation systems. Despite delivering a significant volume of very cost-effective energy reductions, major changes in building management processes and updates to maintenance standards and practices (e.g., through building recommissioning) tend to fall outside of most commercial consumers core business functions. Capturing this potential requires program design that recognizes and works within this paradigm. The potential savings in this end use are significant and have no analogue in the single-family residential segments.

Natural Gas

Table 10-2. Provincial Natural Gas Results

Year	2023	Distribution of Forecast Consumption Across Sectors	Distribution of Potential Across Sectors	2038	Distribution of Forecast Consumption Across Sectors	Distribution of Potential Across Sectors
Sector	Commercial	20%	26%	Commercial	20%	33%
	Residential	39%	30%	Residential	38%	26%
	Industrial	41%	44%	Industrial	42%	41%

Source: Navigant analysis

For natural gas, the energy efficiency potential is much more evenly distributed (i.e., proportional to consumption) across the sectors than for electricity. The fact that the highest proportion of natural gas potential is derived from the industrial sector aligns with the fact that this sector is also forecast to have

---

[76] Note that although the example results discussed are from Scenario C, the distribution of savings across sectors does not vary in any material way across scenarios.

the highest proportion of provincial natural gas consumption. Forecast industrial natural gas energy consumption in 2038 is 42% of total provincial forecast consumption, nearly identical to the 41% of total potential attributed to that sector.

The difference in potential contribution by the commercial and residential sectors exhibits the same trend as for electricity – the commercial sector accounts for a third of the 2038 potential, despite that sector accounting for only a fifth of forecast consumption. In contrast, the residential sector accounts only for approximately a quarter of 2038 potential despite accounting for nearly 40% of natural gas consumption in that year.

This result is driven by two factors: the whole building opportunities in the commercial sector outlined in the electricity section above, and the fact market transformation has resulted in the erosion of potential in residential end uses that may previously have had significant potential. Aerators and showerheads have saturated the market, and baseline water heaters are so efficient that the more efficient versions tend not to be cost-effective. Codes and standards for furnaces are stringent, meaning most of the opportunity remaining in the residential sector are for retrofit-type measures that either deliver relatively modest savings on a per-home basis (e.g., adaptive thermostats), or else are costly and disruptive to install (e.g., insulation, draft-proofing).

10.1.1.2 Integrated Study

For measures that save both electricity and natural gas (dual fuel measures) this study ensured consistency across key input assumptions, such as savings, cost, and expected useful life. For the technical potential and economic potential scenarios, adoption assumptions are consistent across fuel types resulting in a fully integrated study. Likewise, for the Scenario B (max achievable) potential the key scenario assumptions are identical across fuels – incentives are 100% of incremental measure cost – and the results are thus fully integrated. This integration along with the alignment of the electricity and natural gas reference forecasts provides a common framework for evaluating electricity and natural gas measure potential.

For constrained scenarios, however (i.e., Scenarios A through D), the IESO and OEB applied different scenario constraints – for example, in Scenario A, the achievable electricity potential is determined based on a LUEC-based incentive cap. In contrast, the natural gas potential is determined based on a more traditional total program cost-based cap with incentives then allocated to measures based on the natural gas LUECs.

These differing approaches are required since, in Ontario, electricity and natural gas energy efficiency programs are enabled through separate CDM/DSM frameworks and delivered by different entities. These differences result in different approaches to establishing program costs and targets for future CDM/DSM frameworks.

As opportunities for greater integration of electricity and natural gas efficiency programs are explored, opportunities for greater alignment of incentive levels in terms of common unit energy or emissions savings could be considered.

10.1.1.3 Whole Building Analysis

The objective of the whole building analysis (WBA) task was to understand if an econometric (top-down) approach to potential estimation could provide additional insights into segment (or building-type) level results. The achievable potential results of the WBA, undertaken for the hospital segment, were very similar to the achievable potential results for that segment from the measure-level DSMSim analysis: the WBA forecast of hospital electricity potential was just 1% higher than the projection of 2038 potential delivered by DSMSim for Scenario A, and the natural gas prediction was only 8% less than the DSMSim potential from Scenario A.

That said, the results of the whole building analysis are very sensitive to model specification (adding or removing independent variables significantly changes parameter estimates), and the very wide confidence intervals surrounding the predicted results indicate a high degree of uncertainty associated with these results. The sensitivity of the econometric model, and the very high degree of uncertainty associated with the predicted results, are in large part due to the quality and quantity of data available. For example: total incentive payments were available only at a sectoral level; repeating this exercise in future with customer-specific incentive payments would likely reduce the uncertainty band around the point-estimate forecast.

10.1.1.4 Impact of Differences Between Electricity Avoided Costs and Forecast Rates

The forecast differential between electricity avoided costs and electricity retail rates suggests that, going forward, the effectiveness of electricity CDM programs may be determined more by the quality of program design than by the quantity of incentives offered.

One of the most significant drivers of the dynamics observed in the electricity achievable potential scenario results is the large difference between electricity avoided costs and projected electricity retail rates. Through 2035, average residential retail electricity rates are on average approximately *four times* higher than the avoided electricity costs (the difference is smaller in other sectors, but still significant). This dynamic has a profound effect on electricity potential.

- **Low avoided electricity costs relative to retail rates mean only measures with very short paybacks are included in the projected potential.** To be included in the achievable potential, a measure must be cost-effective. Cost-effectiveness is determined by the incremental cost, level and timing of energy savings, and the avoided costs (benefits) associated with those energy savings.
    - Since the avoided electricity costs have decreased in recent years, only electricity measures with a high ratio of energy savings to incremental cost are cost-effective.
    - Projected electricity retail rates are higher than avoided costs resulting in the inclusion of only measures with short payback periods in the achievable potential, even before incentives are applied.
- **Short paybacks mean incentives are less effective at motivating measure adoption.** When measures have short customer payback periods to begin with (i.e., before incentives are applied), the opportunity available for increasing potential by increasing incentives is limited. For example, consider:
    - *Electricity.* Shifting from a LUEC constrained scenario (Scenario A, incentives capped at 2.5 cents/lifetime kWh) to the maximum achievable scenario (Scenario B[77], incentives 100% of incremental cost and "ideal" program adoption parameters) results in an increase in terminal year potential of only 32%.
    - *Natural Gas.* In contrast, for natural gas, where the avoided costs are much closer to projected retail rates, Scenario B's terminal year natural gas potential is *twice* that of Scenario A's. *Where the difference between avoided costs and retail rates is smaller,*

---

[77] It is important to note that in addition to higher incentives, Scenario B also assumes an ideal program design – even if the incentives offered are the same in both scenarios, Scenario B would deliver more potential.

there is more headroom of cost-effective potential that can be accessed with higher incentives.

The assumption of an "ideal" program design in Scenario B is a significant contributor to the headroom mentioned above of additional potential available when incentives are increased. This in turn implies an increasing importance in *administrative* (to enhance program design) over *incentive* spending, as a means to access incremental potential.

What this means – as demonstrated by the sensitivity analysis – is that changes in the avoided costs affect projected electricity potential much more than changes in forecast retail rates. Put another way: the differential between avoided costs and forecast retail rates is such that changes in the latter input leave potential relatively unaffected (modest changes in the payback of measures with very attractive paybacks), whereas changes in the former can materially affect potential (as any cost-effective measure with tend to have a very attractive payback).

10.1.1.5 Lighting Potential

Lighting potential remains a significant source of electricity sector energy consumption savings across all sectors. However, forecast natural conservation in the residential sector (see Section 10.1.1.2) as a result of changes in codes and standards, declining measure incremental cost and other factors means that lighting potential in the terminal year may be lower than in previous studies.

Despite this natural conservation, considerable lighting potential exists (particularly within the commercial sector, where forecast natural conservation is quite low). Ongoing trends in high efficiency (LED) lighting costs, however, mean that the cost of many of the LED lighting measures considered in this study are expected, over the course of the reference forecast period, to drop below the cost of the baseline lighting technologies.

As noted above, when the efficient technology becomes less expensive than the baseline, incentives become an ineffective tool for motivating adoption. In these cases, incremental adoption is motivated by questions of program design, and the balance of costs faced by the program administrator in motivating that adoption shifts from being dominated by incentive costs, to administrative costs (program design, delivery, etc.)

10.1.2 Sector-Level Findings

The following are important findings and observations based on sector specific results, processes, and inputs. This sub-section is divided by sector (residential, commercial and industrial). For each sector, there are a further two to three sub-sections:

- **Results.** A discussion of sector-specific projected potential, by fuel.
- **End Use Intensities.** A discussion of changes in the reference forecast over time, by end use. This applies mostly to electricity, where trends may differ quite significantly across end uses, and only to the residential and commercial sectors, where an estimate of building stock (number of homes, floor space) is available.
- **Delphi Panel.** A discussion of sector specific findings regarding consumer behaviour provided by the Delphi-style panel of experts recruited to help inform this study.

10.1.2.1 Residential

Results

The following are the key findings for the residential sector including the top consumer segments, end uses, and measures in terms of total potential under Scenario C.

Electricity

Table 10-3. Residential Electricity Results

Year	2023	Percent of total sectoral energy savings	2038	Percent of total sectoral energy savings
Top Segments	Single Family Detached Home	46%	Single Family Detached Home	45%
	Low Income Multi-Family	13%	High Rise Multi-Family	13%
Top End Uses	Lighting	52%	Lighting	32%
	Washing/Drying Appliances	14%	Space Cooling	16%
Top Measures	ENERGY STAR LED Specialty Bulbs	31%	ENERGY STAR Clothes Washer	12%
	ENERGY STAR Clothes Washer	12%	ENERGY STAR LED Specialty Bulbs	11%
	LED MR/PAR Lamps	9%	Ductless Mini-Split Heat Pumps	8%

Source: Navigant analysis

- In 2023, the residential sector accounts for approximately a quarter of the total electric energy savings that year and essentially maintains its position in 2038 with 28% of the total electricity energy savings.
- The single family detached home segment accounts for the largest proportion of potential, unsurprising, given that this segment also accounts for the largest proportion of forecast consumption (just under half of residential consumption in both 2023 and 2038). The segment with smallest proportion of potential also makes the smallest contribution to forecast consumption (multi-family low-rise). The most significant deviation between forecast contribution to sectoral consumption and potential is found in two multi-family segments: low income multi-family and multi-family high rises. The forecast 2038 consumption of these two segments is approximately 18% of total consumption, but the energy efficiency potential is 26%. This disproportionate contribution to potential is driven by the presence in these two sectors of opportunities for measures that are typically considered “commercial” opportunities – for example, the measure contributing the ninth highest potential in 2038 is building recommissioning.
- In the beginning of the reference forecast period, lighting is the biggest source of residential potential, delivering more than half of the total residential potential. Over time, potential grows significantly in other end uses relative to lighting (where growth in potential is limited by forecast growth in natural conservation). Space heating and space cooling together account for 20% of potential in 2023, but 30% by 2038.
- This pattern is also evident when the measure-level savings are considered. In 2023, two of the top three highest potential residential measures (contributing 40% of total potential) are lighting measures. In contrast, by 2038 only one of the top three measures is lighting related.
- When contributions to summer peak demand potential are considered, the composition of the top contributing measures changes significantly. Only one of the top 10 contributors to 2038 summer peak demand savings is an LED bulb, whereas seven of the top 10 contributors to peak demand savings are measures related to space cooling and ventilation, in particular ductless mini-split heat pumps account for 17% of summer peak demand savings, and adaptive thermostats account for approximately 10% of summer peak demand savings.

Natural Gas

Table 10-4. Residential Natural Gas Results

	2023	Percent of total sectoral energy savings	2038	Percent of total sectoral energy savings
Top Segments	Single Family Detached Home	45%	Single Family Detached Home	43%
	High Rise Multi-Family	21%	High Rise Multi-Family	21%
Top End Uses	Space Heating	87%	Space Heating	86%
	All (Multiple End Uses)	13%	All (Multiple End Uses)	13%
Top Measures	Adaptive Thermostat	18%	Adaptive Thermostat	17%
	Comprehensive Draft Proofing	17%	Comprehensive Draft Proofing	15%

Source: Navigant analysis

- The distribution of projected potential across segments is similar to that observed for electricity: single family detached homes deliver the highest proportion of savings (expected, given that this segment accounts for the highest proportion of consumption), and the low-income multi-family (not shown) and high rise multi-family segments contribute disproportionately to potential, given reference forecast consumption. These two segments account for 31% (21% from high-rise multi-family and 10% from low-income multi-family) of potential in 2038, but are forecast to consume only 14% of the natural gas used by the residential sector in that year. As in the case of the electricity potential, the key driver here is that large multi-family buildings have commercial building systems, and the opportunity in these segments for building automation systems and recommissioning.
- As expected, Space Heating and All (Multiple End Uses) account for almost all residential natural gas savings, with Space Heating contributing to seven times more potential than the whole building measures[78] end use.
- The highest potential measures for single family buildings tend to be retrofits, rather than equipment replacement. The two measures that contribute the most to natural gas potential are adaptive thermostats (assumed to replace a mix of manual and programmable thermostats) and comprehensive draft proofing. These two measures are the top two contributors to potential in two of the three scenarios, and amongst the top three in Scenario B. This results is a combination of the low market saturation of these measures, and their relatively attractive payback.
- Of the 10 measures contributing the highest potential in 2038, only two (high efficiency fireplace and condensing boilers, together accounting for 15% of residential potential) are single family home equipment measures. Of the remaining seven measures (which account for 75% of the sectoral potential in 2038): three are measures that apply only to multi-family buildings (make up air units, recommissioning or automation systems – 18% of potential) and the remaining five (57% of 2038 potential) are retrofit measures: basement and attic insulation, draft proofing and air sealing, and adaptive thermostats. The reason for this is simply that heating system standards have become increasingly stringent meaning that (for example) forced air furnaces more efficient than the baseline have very long paybacks and tend not to be cost-effective.

End Use Intensities (EUI)

There are significant changes in electricity end use intensities over time. Between 2018 and 2038, the reference forecast predicts a reduction in water heating intensity of nearly 60% and a reduction in the lighting intensity of just over 40%. This has significant implications for potential – the implied high level of natural conservation in the lighting and water heating end uses reduces the potential available in those end uses. In contrast, the reference forecast predicts a 35% increase in miscellaneous residential loads.

---

[78] Referred to in tables and graphs as the “All (Multiple End Uses)” end use.

No such patterns are evident in the reference forecast of natural gas end use intensities. Recall that the electricity reference forecast is developed based on the IESO's end use reference forecast (which has end use and segment-level detail), the natural gas reference forecast is developed based on the natural gas utilities' sectoral-level forecast, allocated by end use based on the findings of the base year disaggregation analysis.

Delphi Panel

Key findings from the Delphi panel style survey and virtual discussion include:

- Residential consumers want to see payback immediately and are unlikely to purchase more efficient but costly measures solely based on energy savings.
- Consumers are more likely to accept longer paybacks for low cost measures than high cost measures.
- A large portion of low-income consumers are renters and would be less likely to accept longer paybacks.
- Consumers in low-income segments are more likely to consider non-energy impacts when deciding whether to adopt energy efficiency measures than customers in non-low-income segments.
- Tenants in multi-unit residential buildings have fewer opportunities or desire to make investments in higher cost energy efficiency measures, regardless of whether they own or rent.

Taken in conjunction with the findings above, these outputs suggest that most of the energy efficiency potential opportunity in the multi-family segment requires the engagement of the building owners or managers, rather than the residents.

10.1.2.2 Commercial

Results

The following are the key findings for the commercial sector, including the top consumer segments, end uses, and measures in terms of total potential under Scenario C.

Electricity

Table 10-5. Commercial Electricity Results

Year	2023	Percent of total sectoral energy savings	2038	Percent of total sectoral energy savings
Top Segments	Other Office	15%	Other Office	15%
	Other Non-Food Retail	12%	Other Non-Food Retail	12%
Top End Uses	Lighting	71%	Lighting	57%
	All (Multiple End Uses)	7%	All (Multiple End Uses)	11%
Top Measures	ENERGY STAR LED Reflector Lamps	16%	LED High/Low Bay Fixtures	11%
	LED Exterior Area Lights	10%	LED Troffers and Suspended Fixtures	10%

Source: Navigant analysis

- In 2023, the commercial sector accounts for 61% of the total electric energy efficiency potential in that year, and 54% in 2038. In contrast, the forecast commercial sector consumption for 2038 is only 37% of provincial consumption. Electricity energy efficiency potential is disproportionately found in the commercial sector.
- The distribution of commercial potential across segments does not change significantly over time, and is reasonably consistent with the distribution of forecast consumption: the other office segment, forecast to make the most significant contribution to consumption in 2038 (19% of total commercial consumption) is also the one predicted by the study to offer the most energy efficiency potential.
- As noted above in Section 10.1.1.5, the lighting end use dominates the commercial sector. Although lighting's contribution to achievable potential falls from 71% (in 2023) to 57% (in 2038) of sectoral potential well over half the electricity potential in the commercial sector remains in lighting in the terminal year. The two reasons this end use dominates the potential in this sector are the very low cost of the measures (as noted above, many LED lighting measures become, over the course of the study, less costly than the associated baseline measure, and the fact that forecast natural consumption is so low. The two most significant non-lighting end uses: the "all" end use (building automation, recommissioning, etc.) and the refrigeration end use together account for approximately 21% of commercial electricity potential by 2038.
- Of the 10 measures contributing most to the 2038 energy potential for this sector, seven are lighting measures. Of the remaining three of the top 10 measures, two are retrofits (recommissioning and furnace tune-ups, and only one is an equipment replacement (HE air source heat pump).
- When contributions to summer peak demand potential are considered, the distribution changes somewhat: although the top three contributors to potential remain lighting measures, the HE air source heat pump climbs the list to the fifth highest contributor, and three lighting measures are replaced in the top 10 contributors by unitary air conditioning units, education and capacity building, and refrigerated display case doors.

Natural Gas

Table 10-6. Commercial Natural Gas Results

Year	2023	Percent of total sectoral energy savings	2038	Percent of total sectoral energy savings
Top Segments	Large Office	15%	Large Office	15%
	Other Commercial	14%	Other Commercial	15%

Top End Uses	Space Heating	81%	Space Heating	84%
	All (Multiple End Uses)	15%	All (Multiple End Uses)	13%
Top Measures	Boilers - Advanced Controls	13%	Condensing Boiler	12%
	Adaptive Thermostats	12%	Demand Control Ventilation	11%

Source: Navigant analysis

- The distribution of potential by segment is consistent across the reference forecast period. The most significant way in which the distribution across segments of commercial potential differs from forecast commercial consumption is that the other office segment is contributing disproportionately little potential – although this segment accounts for 15% of 2038 commercial potential, it accounts for 27% of forecast commercial consumption. The relatively low contribution to potential from this segment is driven by the end use distribution: for this segment, the potential from the All (Multiple End Uses) is smaller than for the other segments in this sector. It seems likely that the primary reason potential for this segment is low relative to the reference forecast is that this segment is dominated by smaller buildings that have fewer opportunities for energy efficiency via whole building type measures.
- As seen on the residential natural gas side, Space Heating and All (Multiple End Uses) account for almost all residential natural gas savings with Space Heating contributing to seven times more potential than the "All (Multiple End Uses)" end use.
- Unlike the residential sector, the measures contributing most to the commercial potential exhibit greater balance in terms of retrofits vs equipment with more efficient combustion. Three of the top 10 measures (condensing boilers, gas fired rooftop units, and gas fired heat pumps) fall into this latter category. Of the remaining seven measures in that top ten, five target natural gas savings through some type of ventilation improvement (demand control ventilation, building recommissioning, make up air units, air handlers and kitchen demand control ventilation). This finding in particular – that a high proportion of potential can be attained through ventilation measures that reduce natural gas space heating consumption – accords closely with feedback contributed by stakeholders attending the study's Advisory Group meetings.

End Use Intensities (EUI)

Electricity energy intensity is much more static in the commercial sector, resulting in a significantly different distribution of potential across end uses compared to the residential sector. In contrast to the residential sector, the reference forecast predicts a decrease of only 2% between 2018 and 2038 in lighting intensity. The largest reductions in end use intensity are for the water heating (30% reduction) and refrigeration (28% reduction) end uses. This allows significantly more "headroom" for acquiring lighting savings, compared to the residential sector.

No such patterns are evident in the reference forecast of natural gas end use intensities. Recall that the electricity reference forecast is developed based on the IESO's end use forecast (which has end use and segment-level detail), the natural gas reference forecast is developed based on the natural gas utilities' sectoral-level forecast, allocated by end use based on the findings of the base year disaggregation analysis.

Delphi-Panel

Key findings from the Delphi panel style survey and virtual discussion include:

- Institutions are more willing to accept longer payback periods than private businesses.
- Commercial consumers are not willing to commit to technologies with long paybacks, particularly if it is new technology and the savings less certain.

- Consumers have more understanding and willingness to invest in measures where the non-energy benefits are immediate and obvious (e.g., improved lighting quality with LEDs).
- A shortage of skilled trades-people may slow the pace of adoption, particularly for whole building measures that require energy efficiency focused expertise (e.g., advanced controls and automation, recommissioning and equipment upgrades)

10.1.2.3 Industrial

Results

The following are the key findings for the industrial sector including the top customer segments, end uses, and measures in terms of total potential under Scenario C.

Electricity

Table 10-7. Industrial Electricity Results

Year	2023	Percent of total sectoral energy savings	2038	Percent of total sectoral energy savings
Top Segments	Mining, Quarrying and Oil & Gas Extraction	21%	Mining, Quarrying and Oil & Gas Extraction	17%
	Agriculture	15%	Other Industrial	13%
Top End Uses	Compressed Air	36%	Motors - Pumps	31%
	Motors - Pumps	29%	Compressed Air	31%
Top Measures	Air Compressor Optimization	20%	Pump System Optimization	20%
	Pump System Optimization	18%	Air Compressor Optimization	12%

Source: Navigant analysis

- The industrial sector's relative contribution to total provincial potential grows over the years, from 12% of potential in 2023, to 18% in 2038. Potential from the industrial sector is low relative to its consumption: the industrial sector contributes approximately 29% of total forecast electricity consumption in 2038.
- The most significant change in the distribution of potential by segment across time is the shift in the contribution of the agriculture sector and in the mining quarrying and oil and gas extraction segment. Combined, these sectors contribute approximately 30% of potential in 2038, but approximately 36% in 2023.
- Compressed air and motors – pumps have the greatest potential together accounting for nearly two thirds of total industrial potential in 2038. The remainder of the electricity energy potential is dominated by the "All (Multiple End Uses)" category. Altogether, in 2038, only 20% of the industrial potential does not fall in one of those three end use categories.
- As would be expected, given the end use potential, compressed air and motors - pumps measures dominate the list of measures that contribute to most potential – the top five measures include two pump motor measures (pump system optimization, and pump equipment upgrade), two compressed air measures (aid compressor optimization and air leak survey), and one all (multiple end uses measure (recommissioning).
- The top 10 measures contributing to summer peak demand potential are nearly the same as those contributing to energy potential (expected, given industrial load shapes), with the only change in the top 10 contributors, being the replacement of greenhouse grow lights (tenth highest contribution to energy potential) by fan system optimization.

Natural Gas

Table 10-8. Industrial Natural Gas Results

Year	2023	Percent of total sectoral energy savings	2038	Percent of total sectoral energy savings
Top Segments	Plastic and Rubber Mfg	20%	Primary Metals Mfg	24%
	Agriculture / Primary Metals Mft	18% each	Plastic and Rubber Mfg	19%
Top End Uses	Process Heating (Water/Steam)	39%	Process Heating (Direct)	57%
	Process Heating (Direct)	41%	Process Heating (Water/Steam)	25%
Top Measures	Boiler Upgrade	35%	Process Heat Improvements	31%
	Process Heat Improvements	20%	Boiler Upgrade	20%

Source: Navigant analysis

- The distribution of energy efficiency potential across segments is relatively stable over the reference forecast period, with material changes only in two segments: the agriculture segment accounts for 18% of industrial potential in 2023, but only 12% in 2038. In contrast, the primary metals manufacturing segment accounts for 18% of industrial potential in 2023, but 24% in 2038. This shift is due to the growth in the potential associated with direct process heating.
- Process heating (direct and water/steam) end uses account for over 80% of the potential of this sector.
- Process heat improvements and boiler upgrades are the top contributors to the industrial potential through the course of the reference forecast period, and account for over half of the industrial potential. Other measures that contribute significant amounts of potential include gas heat recovery, recommissioning, and improved controls.

Industrial Assessment Center

Industrial sector measures are all drawn from the Industrial Assessment Center's (IAC)'s database. These are based on efficiency recommendations derived from energy audit findings. Although the IAC database remains the best source for industrial energy efficiency savings, it seems unlikely that auditors would recommend measures that they knew were highly unlikely to be technically feasible or cost-effective, resulting in the observed result that for both electricity and natural gas, Technical and Economic potential are quite similar.

Estimated industrial sector potential savings may be conservative (low) because highly customized opportunities (for specific segments or facilities) could not be considered due to lack of data available for characterizing those measures. It is possible that more potential could be attained than is reported here by carefully targeting high opportunity sites and deploying professional energy auditors to seek out facility-specific opportunities for savings.

Delphi-Panel

Key findings from the Delphi panel-style survey and virtual discussion include:

- Even more so than the commercial sector, industrial consumers tend to focus only on matters related to core business functions: without significant interventions these customers do not tend to explore the possibilities offered by energy efficiency.
- Energy efficiency projects need to have immediate paybacks to proceed – industrial consumers have a very steep payback acceptance curve.

- Some customers willing to accept paybacks longer than 1 to 2 years are implementing energy efficiency projects for other non-energy related reasons (i.e., health and safety, standard compliance, etc.)
- Agriculture segment tends to have a longer-term outlook (i.e., can accept longer paybacks compared to manufacturers; manufacturers are tied to distribution contracts which limits them to adopting measures with shorter paybacks).
- Awareness level of process and equipment optimization types of measures is lower than awareness of equipment upgrade measures due to vendor business development activity.

10.2 Recommendations

The purpose of this section of this chapter is to highlight key lessons from the development of this study and identify where there are successes to retain for future studies, and where improvements could be made.

10.2.1 Successes to Retain

Features of the current study that Navigant found greatly assisted with the work include the following:

- **Integration of electricity and natural gas analysis.** This study marks the first conservation potential study for the province of Ontario conducted by the IESO and the OEB capturing both natural gas and electric potential simultaneously. This provided opportunities for collaboration and resulted in:
    - *Consistent measure characterisation.* Characterizing both natural gas and electricity measures ensured consistency in naming conventions and input assumptions, enhancing the usefulness of outputs for future collaboration opportunities.
    - *Capturing full measure value.* Dual fuel measures (i.e., those that save both electricity and natural gas) were screened for cost-effectiveness using the most recently available avoided costs for both fuels – this ensured (for example) that the full value of measures that save primarily natural gas, but also reduce summer peak electricity demand, was considered.
    - *Confidence that reference forecasts are compatible.* A key task of the reference forecast development was ensuring compatibility of the assumptions in the natural gas and electricity input forecasts. Explicitly assessing this (and determining that the forecasts are, in fact compatible) helps to ensure that estimated potential savings across fuels are harmonized across a reasonably consistent set of input assumptions.

  The possibility of greater integration remains, and Navigant would recommend that the IESO and OEB consider aligning scenario constraints across fuels for future studies.
- **Residential End Use Data.** IESO's 2018 Residential End Use Survey (REUS) was valuable for both the electric and natural gas measures, ensuring that many key measure inputs (such as measure density and saturation) for the residential sector were based on locally specific findings, rather than assumptions derived from other jurisdictions.
- **Estimating fuel switching potential and energy efficiency potential in separate, parallel, analyses.** In the 2016 OEB potential study, fuel switching was combined with energy efficiency potential. This resulted in – for some end uses in some sectors – some confounding effects, as the technical potential of fuel switching measures will always exceed that of competing energy efficiency measures. The approach used for this study – separating fuel switching from energy

efficiency – ensures greater consistency in the list of measures contributing to potential when the cost-effectiveness test is applied to technical potential to deliver economic potential.

- **Advisory Group input and third-party review of measure assumptions.** The APS AG provided valuable insights and expertise from the project initiation and contracting through to the to implementation and presentation of results. This input as well the review of measure level assumptions provided by the Measure Review Subcommittee helped ensure the study aligned with best practices in potential modelling and reflected the realities of the Ontario market.
- **Leveraging sector experts to understand customer behaviour.** The 2019 APS used a Delphi workshop approach to develop consumer measure adoption parameters (e.g., payback acceptance, awareness and ability to adopt, etc.). This process helped align the quantitative adoption inputs the experience of sector experts and also identified opportunities to improve program delivery and reduce market barriers.

  Room of improvement does exist for this component. Resolving questions of consumer behaviour (price- and non-price driven) is a complex and inherently uncertain exercise as it requires assigning values to relationships that cannot be observed. These are questions of sufficient complexity that they should be the subject of a dedicated study, rather than just one component of the potential study.

  Navigant would recommend that the IESO and OEB consider expanding the scope of future studies of consumer price sensitivity to explicitly consider how consumers make efficient technology adoption decisions. The terms of reference for such a study should be carefully scoped to ensure that the estimated output relationships (e.g., the impact of non-energy benefits on payback acceptance, etc.) can be characterized in a sufficiently simplified manner that they can be relatively easily adapted to whichever potential estimation model is to be used for the next study.
- **Quantifying uncertainty.** Potential studies make extensive use assumptions and estimated values. These are modelled using estimated relationships and a variety of (necessity-driven) simplifying assumptions. Like all forecasts or estimates, this means that results must inherently be uncertain. The sensitivity analysis in the 2019 APS, in quantifying the impact of changes in key input parameters on outputs, provides an estimate of the uncertainty of results with respect to those key inputs.

  This element of the study should be enhanced in future studies, and going forward, Navigant would recommend that greater emphasis be placed on the *range* of estimated savings potential estimated. Putting considerations of uncertainty front and centre – underlying the know fallibility of the forecast – will better allow policy-makers to understand the materiality of changes in results, or differences in results (to other studies, between various segments, etc.), as discussed in the Recommendations section.

10.2.2 Recommended Improvements

Navigant has divided the recommended improvements in three sections:

- **Inputs.** Recommendations to be considered by the IESO and OEB related to input data development that could improve the robustness and applicability of results, and address some stakeholder concerns, particularly regarding larger commercial and industrial buildings and installations.
- **Methodology.** Recommendations to be considered by the IESO and OEB related to the approaches used to estimate and to report potential.
- **Process.** Recommendations to be considered by the IESO and OEB related to how the overall process of potential study development can be improved.

10.2.2.1 Inputs

- **Collect commercial and industrial end use data.** Potential estimation would benefit significantly from the availability of up-to-date provincial baseline and end use studies, particularly for the commercial and industrial sectors. The IESO and OEB should consider conducting a combined dual fuel end use and baseline study to act as an input to a future potential study. Ideally, this study should be an on-going effort to quantify the energy-consumption characteristics of consumers and tracking how these change over time, with periodic sectoral updates (e.g., year 1, update residential, year 2, update commercial, year 3 update industrial, year 4, update residential, etc.). Such a study (or group of studies) should also capture a snapshot of technologies in place (baseline and efficient) and identify (where feasible) the characteristics of baseline replacement technologies (i.e., the equipment that would replace the currently installed technology, absent any energy efficiency programs). The benefits of such an exercise would include:
    - *Alignment with the measure list or TRM.* Should the IESO and OEB proceed with the development of an integrated and comprehensive TRM, the baseline study could be used to periodically update that document's assumed baseline, effective full load hours, etc. This would ensure consistency in measure characterisation.
    - *Greatly improved visibility into large commercial and industrial baseline conditions and energy efficiency opportunities.* At present baseline information for large buildings and equipment installations is extremely sparse in Ontario. The idiosyncratic and geographically specific nature of these installations mean that relying on estimates or assumptions developed for other jurisdictions can be problematic. One of the key findings of this study was that there appears to be a material energy efficiency opportunity in whole building solutions (captured by the "All (Multiple End Uses)" end use), and that the industrial sector savings data available through the IAC may understate potential in that sector. A baseline study would provide data to remedy this.
    - *A better understanding of the uncertainty of estimated potential.* The recommendation that future studies continue to improve the quantification (and presentation) of the uncertainty associated with estimated outputs will be made significantly easier should there be a better (quantifiable) understanding of the uncertainty associated with some of the key inputs – in particular surrounding baseline conditions.
- **Develop an integrated Technical Reference Manual (TRM).** The IESO and OEB should consider making a collaborative effort to develop and maintain a comprehensive TRM of energy saving measures. This should be revisited periodically and expanded (to accommodate emerging measures brought forward by IESO or OEB staff, or stakeholders) and updated (as baselines change) on a regular (annual or semi-annual) basis. Going forward, potential studies should consider only measures included in the TRM.

  This will ensure greater planning certainty (no ambiguity as to what should be considered), continuity of inputs from study to study and considerably reduce the time required to establish the study measure list. In addition to the standard TRM inputs (e.g., base and efficient consumption, expected useful life, etc.) this should include metrics derived from a baseline study (see below) to approximately quantify the applicability of the measure (i.e., analogous to measures of density and saturation used as part of this study).
- **Ensure the costs of natural gas expansion are properly accounted for within the natural gas avoided costs.** It is unclear to what degree the natural gas avoided costs account for the costs associated with natural gas infrastructure expansion. For example, when considering fuel switching for new construction, it seems likely that the existing avoided costs would understate the benefit of not having to install pipelines and access points to a new housing development. If it can be demonstrated that the existing avoided costs do not account for these costs, or do not account for them specifically in the case of new construction, the OEB should consider

developing (or engaging others to develop) another set of avoided costs that does. These could then be used for future fuel switching studies where there is an expectation of meaningful growth residential and commercial building stock.

10.2.2.2 Methodology

- **The granularity of the analysis should be determined by the available granularity of input data. Where highly granular data are not meaningfully different across categories, the analysis should take place at an aggregated level.** Specifically, for any future studies, the IESO and OEB should consider requiring that the analysis be conducted at the weather zone/provincial level. Where more granular results are required (e.g., as inputs in downstream analyses conducted by the IESO, OEB or other agencies using the outputs of the potential study) these should be developed through a simple allocation approach.

  For this study, Navigant conducted the analysis at the IESO transmission zone level of granularity. This may have been of limited value. The benefits of doing so were relatively small: very few input data were available at the zonal level of granularity, and where zone-specific data were available (e.g., through the REUS, or from the IESO planning group) the uncertainty associated with these values made them problematic to use. In contrast, the cost of conducting the analysis at this level (rather than using more aggregated set of data and allocating results in a post-processing step) was significant.
- **Additional research on the measure stacking could help identify how much value exists in controlling for it and may be helpful in program design.** The net effect of measure stacking for achievable potential in this study was trivial. One reason for this is that Navigant – lacking better information – assumed that individual measure adoption choices were independent of one another.79 Additional consumer research (via surveys and/or focus groups) could help determine whether in fact there exists any meaningful relationship between measure adoption and measure stacking. Such a finding would be helpful for program design and future studies. If it is determined that no additional research in this area is necessary, or if it is found that consumers tend to avoid stacking measures (e.g., consumers recognize the declining marginal benefit of adopting measures that stack), then the IESO and OEB should consider removing consideration of this interactive effect for the next study.

10.2.3 Process

- **Review frequency of APS updates.** Efficiencies in estimation could likely be realised by moving from a triennial to annual potential study cycle, with a different sector's potential being quantified each year. The IESO and OEB should consider for example a system that updates each sector's potential every three years, but on an ongoing annual sector-by-sector basis. So, for example (similar to the baseline study recommendation above), in year 1 residential potential is updated, in year 2, commercial potential is updated, in year 3 industrial potential is updated, and in year 4 residential potential is updated again, etc. This would likely allow for a leaner, more focused effort, and (as an on-going process) ensure greater consistency of inputs, methods and outputs over time.
- **Measure characterization should follow development of the reference forecast.** One challenge for this study was the need conduct tasks in parallel which are more efficiently completed in series. Measure characterization, for example, should follow the completion of the reference forecast. This can be used to ensure that measure density and saturation assumptions are calibrated to the reference forecast and reduce the need of time-consuming re-work and

---

[79] That is, Navigant assumed that if 50% of the population acquired an engine measure, and 50% acquired an envelope measure, 25% would have both, stacked (the stacking frequency variable).

diagnostic analysis. Consider, for example, residential lighting measures. The density and saturation values for these measures were characterized prior to receipt of the reference forecast (which assumes significant natural conservation in this end use). These required revision following intake of the reference forecast to ensure that potential didn't exceed forecast consumption in the later years of the study. Had the reference forecast work been completed prior to measure characterization, the issue of natural conservation for this end use could have been addressed in the first pass.

- **The measure input review should take place as part of the quality control process applied to the technical potential.** Following from the recommendation above, the process would be: develop reference forecast, then measure characterisation, then technical potential, then review measure characterisations for errors and omissions. As part of this potential study, the measure review sub-committee reviewed measure characterisations before estimated technical potential values were available. Most measure parameters cannot be completely reviewed before understanding how they scale in the model and their direct impact on the base year and reference forecast end use data. For the commercial and industrial sectors, the measure level inputs could not be reviewed without understanding their impact on the resulting potential. This resulted in a two phased review of measure characteristics. In order to avoid an unnecessary duplication of efforts, the measure characterization review process should be scheduled to be conducted during the technical potential review phase.

Appendix A. BASE YEAR DISAGGREGATION

A.1 Data Sources

Table A-1 provides a comprehensive summary of the data sources used by Navigant throughout the BYD task.

Table A-1. Data Sources Used

Data Type	Data Source	Workbook(s) Destination	Description of Data
2017 Electricity Consumption	IESO	**Electric:** Residential, Commercial, Industrial	kWh consumption for all 10 IESO zones, disaggregated by IESO segment and end use
2017 Natural Gas Consumption	Natural Gas Utilities	**Gas:** Residential, Commercial, Industrial	m^3 consumption for all utility natural gas regions, disaggregated by segment[80]
2014 End Use Intensities	OEB	**Gas:** Residential, Commercial	Consumption per household (Residential) or per square foot (Commercial) from previous natural gas potential study
2017 Housing Forecast	IESO	**Electric:** Residential **Gas:** Residential	Residential households, by IESO segment and IESO zone in base year
2017 Commercial Floor Space	IESO	**Electric:** Commercial **Gas:** Commercial	Commercial square footage, by IESO segment and zone in base year
2017 Data Centre Floor Space	IESO	**Electric:** Commercial	Data centre-specific Commercial square footage, by IESO zone[81])
Low income Housing Stock	IESO	**Electric:** Residential **Gas:** Residential	Percent of household stock classified as low income, subdivided by Single-family and Multifamily dwellings, by IESO zone
Residential End Use Survey Data	IESO	**Electric:** Residential **Gas:** Residential	Survey data used to better understand differences in low income and non-low income energy intensities
Agricultural End Use Allocation Factors	Previous Navigant Canadian Potential Studies	**Electric:** Industrial **Gas:** Industrial	Percent of segment-level natural gas consumption allocated to each end use
Agricultural End Use Allocation Factors	EIA	**Electric:** Industrial **Gas:** Industrial	Percent of segment-level gas consumption allocated to each end use
Wastewater End Use Allocation Factors	IESO	**Electric:** Industrial **Gas:** Industrial	Percent of segment-level gas consumption allocated to each end use

Source: Navigant analysis

---

[80] In some cases, some proportion of segment consumption could not be provided for a specific IESO zone. Details regarding Navigant's approach to the regional allocation of these values are provided below.

[81] Data Centre floor space included in IESO's Other Commercial floor space estimate. These data were used to extract Data Centre share from that IESO segment.

A.2 Detailed Methodology

This section of the BYD appendix provides a more detailed description of the approach used by Navigant to disaggregate the data provided by the IESO and the natural gas utilities into the format required for this potential study. It is divided into following sub-sections:

- Residential
- Commercial
- Industrial

Each of these sub-sections describes the approach common to both fuels, and then provides additional detail regarding specifics of the electricity disaggregation, followed by specifics of the natural gas disaggregation.

The key criteria used to select the segments and end uses to include in the potential study were:

1. **Availability of Data:** Do the data exist to support a reasonably accurate disaggregation of consumption and stock to this segment and end use?
2. **Energy Use:** Does the segment or end use consumption contribute a meaningful proportion of overall sector load? In some cases, a segment or end use may be considered that does not currently contribute much load but is expected to grow materially in the future (e.g., data centres).
3. **Differentiation:** Is the selected segment or end use meaningfully different (in terms of end use intensities and technology densities) from all others into which it might otherwise be aggregated (e.g., this potential study includes both high rise and low rise multi-residential segment due to building code differences and observed differences in lighting and space cooling intensities).

A.2.1 Residential

The BYD activity common to both electricity and natural gas was the allocation of housing stock into the segments required by Navigant for the potential study.

Electric Residential Methodology

The IESO provided Navigant with residential electricity consumption broken out by IESO zone, segment and end use. In cases where IESO segments or end uses did not match those required for the potential study, these were aggregated[82] or allocated out[83] to deliver the consumption by the required segments and end uses. More specifically, the IESO's planning group end uses were grouped together to align with the requirements of the potential study, and Navigant split out consumption from IESO planning group's segments to deliver a set of two additional low income segments.

IESO End Use Forecast and Planning Inputs

Electricity base year data are all outputs from the IESO's End Use Forecaster (EUF) model. This model also delivers the reference forecast used by the potential study, and by the IESO itself for other planning purposes. The EUF is an end use model that tracks equipment and building stocks over time and

---

[82] For example, the potential study end uses AC_Central and AC_Room were both aggregated into the potential study Space Cooling end use.

[83] Only applied to obtain the low income / non-low income split.

simulates technology acquisition in the economy. The residential, commercial/institutional, and industrial sectors are each analyzed separately.

The base year data are derived for historical years by calibrating model inputs with historical realised consumption values. Both consumption and stock (household count) values align with IESO planning team models and assumptions to ensure consistency between the potential study and the IESO's long-term forecast (i.e., the Ontario Planning Outlook).

Low Income Segment Disaggregation

The segments and end uses included in the data provided by the IESO's planning team are generally consistent with those used for the 2019 potential study with a few exceptions. Within the residential sector, the IESO does not break out low income residential segments (i.e., low income single-family and low income multifamily) in their typical business and planning activities, however, the Project Team, based on input from stakeholders, directed Navigant to create these new segments for the potential study to capture these customers' unique consumption profiles and programmatic needs.

Table A-2 shows the proportion of households per segment group (single-family and multifamily), and by IESO zone in the low-income category. The IESO provided Navigant with this data, obtained through a custom query of Statistics Canada's 2016 Census Income Highlight Tables (population in private households for income status, number of persons in low income, etc.).

Table A-2. Residential Low Income Households

IESO Zone	Single-family (% Low income)	Multifamily (% Low income)
Bruce	24%	62%
East	24%	58%
Essa	22%	50%
Niagara	19%	42%
Northeast	22%	56%
Northwest	25%	56%
Ottawa	25%	54%
Southwest	15%	40%
Toronto	19%	49%
West	25%	58%

Source: Navigant analysis

For these end uses, the REUS indicated that, on average in Ontario,[84] for single-family households:

- A low income household's primary space heating equipment was more likely to be fuelled by electricity (31% of households) than non-low income household's (16% of households).
- A low income household's water heating equipment was more likely to be fuelled by electricity (41% of households) than a non-low income household's (25% of households).
- A low income household was less likely to have space cooling equipment (88% of households) than a non-low income household (94% of households).

---

[84] Statistics differentiating low income and non-low income fuel shares are available at acceptable levels of significance only at the provincial level, and not by IESO zone.

Using the REUS provincial values, Navigant applied an adjustment to the relevant zonal low income and non-low income end use intensities, such that overall sectoral consumption values by zone and IESO segment still matched those values provided by the IESO.

REUS data at an acceptable level of significance were not available to develop a similar adjustment for multifamily households. In this case intensities were assumed to be the same for both low income and non-low income households.

Natural Gas Residential Methodology

Navigant received base year natural gas consumption from the natural gas utilities. Consumption data was provided at the segment-level – end use consumption was not provided. Consumption was also mapped to the natural gas regions, and at least partially mapped to IESO zones.[85]

In the dataset received from Union Gas, 12.5% of consumption was not definitively aligned to an IESO zone, and 1.5% of consumption was not definitively aligned to a segment. In the data provided by Enbridge Gas, 0.4% of consumption was not mapped to an IESO zone.

Geographic and Segment Mapping

Base year consumption provided by the utilities that was not assigned to a segment or IESO zone was mapped across the remaining IESO zones and segments proportionally based on the known consumption, with some ad hoc adjustments applied in the calibration stage (see below) to correct for obviously unreasonable output intensity values.

Unmapped consumption across the two utilities accounts for 72.6 million cubic meters of natural gas consumption, less than 1% of total residential base year consumption.

Natural Gas-Connected Stock Estimation

Navigant used the REUS to determine the percentage of households, by IESO zone, that have a natural gas connection to determine a natural gas-connected housing stock. The REUS provides the percentage of households using natural gas as their primary fuel for space heating – this value was used as a proxy for natural gas connection. The zone-specific fuel share derived in this fashion was applied across all segments in each IESO zone.[86]

As part of the calibration stage (see below) some ad hoc adjustments were applied to multifamily fuel shares (for example, when the first-pass delivered unexpected intensity values due to the combined effect of comparing disparate data sources in smaller-population zones).[87] Table A-3 shows the natural gas-connected fuel shares for single-family and multifamily households by zone.

---

[85] All potential study outputs will be available at the IESO zonal level, for both fuels. This requires all modelling to be conducted at the IESO zone level, and therefore requires a reference forecast (and base year disaggregation) of all consumption to the IESO zonal level.

[86] The REUS does provide a separate estimate of the distribution of primary heating equipment fuel for multifamily and single-family, but the values for the multifamily were, from the perspective of this potential study, considered unreliable. The REUS tracks only in-unit equipment, thus a consumer living in a building with a central gas boiler, but with some in-unit auxiliary electric baseboards would (in the REUS) be considered an electric heating household, despite the fact that most of the unit's thermal load was met by the central gas-fired heating equipment.

[87] An end use natural gas intensity is a function of estimated natural gas end use consumption (adapted by Navigant from utility-provided data), estimated proportion of households with access to natural gas (estimated by the IESO's REUS), and the number of households in a given IESO zone (estimated by the IESO). In some zones (e.g., Bruce) the very small population makes intensity values very sensitive to statistical noise. The ad hoc changes applied by Navigant were correct for that noise.

Table A-3. Residential Gas Fuel Shares by IESO Zone

IESO Zone	Single-family Fuel Share	Multifamily Fuel Share
Bruce	45%	6%
East	61%	15%
Essa	70%	18%
Niagara	84%	84%
Northeast	70%	70%
Northwest	70%	70%
Ottawa	88%	88%
Southwest	86%	86%
Toronto	87%	87%
West	83%	83%

Source: Navigant analysis

Natural gas-connected household stock was calculated by multiplying total households by the fuel shares in Table A-3.

End Use Mapping

Base year natural gas consumption data provided by the natural gas utilities was not mapped to any end uses. Navigant's procedure for disaggregating segment-level consumption to the end use took the following steps:

1. **2016 Natural Gas Conservation Potential Study EUIs.** Initial EUIs are drawn from the 2016 Natural Gas Conservation Potential Study.
2. **Calculate Uncalibrated Consumption.** The input EUIs are multiplied by the natural gas-connected floor space (see above) to deliver a segment- and zone-specific consumption value.
3. **Calibrate EUIs**. The deviation between uncalibrated consumption (step immediately above) and utility-provided segment/zone consumption is used to calibrate segment- and zone-specific EUIs.
4. **Calculate End Use Consumption.** Calibrated EUIs are applied to natural gas-connected stock values to deliver segment, end use and zone-specific natural gas consumption values that, in aggregate, match the values provided by the natural gas utilities.

Some additional adjustments applied as part of the end use mapping process include: adjusting fuel shares or the geographic mapping of unallocated consumption and adjusting low income space and water heating intensities to reflect the changes made to the electric space and water heating energy intensities (see above for more details).

A.2.2 Commercial

The BYD activity common to both electricity and natural gas is the allocation of commercial floor space into the segments required by Navigant for the potential study.

Commercial Floor Space

The IESO provided an estimate of base year commercial floor space by IESO zone and segment. Segments used by the IESO planning team were mapped to the selected potential study segments.

Table A-4 shows the total floor space per segment used throughout the analyses.

Table A-4. Commercial Floor Space Stock by Segment

Segment	Commercial Floor Space (million square feet)
Food Retail	61.4
Hospital	64.8
Large Hotel	53.6
Large Non-Food Retail	67.4
Large Office	298.1
Long-Term Care	154.6
Other Commercial	448.5
Other Hotel/Motel	53.6
Other Non-Food Retail	386.8
Other Office	704.2
Restaurant	52.2
School	287.2
University/College	132.7
Warehouse	498.4
Data Centre	2.0
Total	**3,265.5**

Source: Navigant analysis

Electric Commercial Methodology

Navigant received base year electricity consumption data, by zone, segment and end use, from the IESO. Additional adjustments required to deliver consumption values (and EUIs) necessary for the analysis were limited to:

1. Disaggregating data centre consumption from the IESO other commercial buildings segment
2. Allocating that consumption appropriately across end uses

The total volume of data centre consumption, by zone, was estimated by applying a segment-level energy intensity obtained from a Natural Resources Canada report[88] to the data centre floor space estimate described above.

This segment-level consumption was allocated to the various end uses based on information provided by a 2016 Institute of Electrical and Electronics Engineers report Data Center Energy Consumption Modeling: A Survey.[89] This report provided Navigant with an end use breakdown of electricity consumption in data centres as a percentage of total consumption.

Natural Gas Commercial Methodology

Navigant received base year natural gas consumption from the natural gas utilities. Consumption data was provided at the segment-level; end use consumption was not provided. As with the residential

---

[88] “Data Center Estimates in the United States and Canada.” Available: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/pdf/benchmarking-rendement/DataCenter-US-and-Canada-EN-Feb2018.pdf

[89] M. Dayarathna, Y. Wen, “Data Center Energy Consumption Modeling: A Survey.” Available: https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7279063

disaggregation, some consumption data provided by the utilities was not mapped to an IESO zone. The IESO zone was unknown for 26% and 24% of total consumption from Union and Enbridge, respectively.

Geographic Mapping and Re-Mapping

Base year consumption provided by the utilities that was not assigned to a segment or IESO zone was mapped across the remaining IESO zones and segments proportionally based on the known consumption. Ad hoc adjustments to this distribution were made in the calibration stage (see below) to correct for obviously unreasonable output intensity values.

In a very small number of instances, consumption was reported by the natural gas utilities in segment/zone combinations where the IESO's floor space forecast reported zero floor space (e.g., Northwest zone, large office segment). In these instances, consumption was re-mapped to other segments on an ad hoc basis (using the example above, large office consumption in the Northwest zone was re-mapped to the other office segment in that zone).

Natural Gas-Connected Stock Estimation

Navigant developed an initial natural gas-connected fuel share (by IESO zone) through a comparison of customer counts. The total number of commercial consumers by zone were obtained from the 2017 OEB Yearbook of Electricity Distributors.[90] The natural gas fuel share was calculated by dividing zonal customer counts provided by the natural gas utilities by the total number of electricity customers derived from the OEB Yearbook.

These initial fuel share values were then applied to IESO provided commercial floor space (providing an initial estimate of natural gas-connected floor space), which were in turn applied to the EUIs developed as part of the 2016 Natural Gas Conservation Potential Study. This value (an estimated total provincial commercial natural gas consumption) was then applied to *actual* total provincial natural gas consumption provided by the natural gas utilities to provide a calibration or scaling factor. Finally, this factor was applied to the initial estimated fuel share to deliver a final estimated fuel share, by zone.

This final estimate of the proportion of commercial floor space by zone that is natural gas-connected (shown in Table A-5) was presented to representatives of both natural gas utilities for review and was deemed reasonable by those representatives.

Table A-5. Calibrated Commercial Natural Gas Fuel Share by IESO Zone

IESO Zone	Calibrated Natural Gas-Connected Fuel Share
Bruce	51%
East	57%
Essa	71%
Niagara	64%
Northeast	80%
Northwest	71%
Ottawa	62%
Southwest	71%
Toronto	92%
West	98%
Ontario	**79%**

Source: Navigant analysis

---

[90] On the assumption that all natural gas consumers are also electricity consumers.

Ad hoc adjustments were made to the fuel shares of some segments in some zones. In segment/zone combinations where the calibrated energy intensity was more than three times the provincial average for that segment, the fuel share for that segment (in the given zone only) was increased by 25%. In segment/zone combinations where the calibrated energy intensity was less than one-third the provincial average for the given segment, the fuel share for that segment/zone was decreased by 25%.

The calibrated fuel shares were used to develop a final natural gas-connected floor space stock, by multiplying the fuel shares and the IESO floor space forecast.

End Use Mapping
Base year natural gas consumption data provided by the natural gas utilities was not mapped to any end uses. Navigant's procedure for disaggregating segment-level consumption to the end use, and obtaining segment specific EUIs is the same for the commercial as for the residential sector (see above).

A.2.3 Industrial

No stock was used for the industrial disaggregation. Since industrial energy use is driven more by processes and production than by building floor space, the IESO does not develop industrial building stock forecasts, nor does it disaggregate the agriculture and water and wastewater treatment segments by end use for its regular business and planning purposes so this information was not available. The absence of stock means that no intensities were developed for this sector. This affects how the input forecasts provided by the IESO and the natural gas utilities are disaggregated for the development of the reference forecast.

Industrial Segment Descriptions

Table A-6 includes definitions of each industrial segment, which aligns with the definitions used in IESO's base year data.

Table A-6. Industrial Segment Definitions

Potential Study Segment	Example of Industry Types
Chemicals Mfg	Manufacturing of chemicals from petroleum and coal products
Fabricated Metals Mfg	Fabricated metal product manufacturing (for example, sheet metal, iron and steel forging, metal stamping, etc.)
Primary Metals Mfg	Manufacturing of ferrous and non-ferrous metals, including iron, steel, aluminum, copper, etc.
Mining, Quarrying and Oil & Gas Extraction	Mining facilities and associated load (for example, oil & gas extraction, ore mining, quarries, etc.)
Transportation and Machinery Mfg	Automotive and automotive-parts manufacturing, as well as other transportation equipment manufacturing (for example, aircraft engines)
Nonmetallic Minerals Product Mfg	Manufacturing of nonmetallic minerals, including brick, clay, ceramics, glass, and concrete products
Food and Beverage Mfg	Facilities involved in manufacturing food and beverage products (for example, mills, cheese manufacturing, breweries, distilleries, commercial bakeries, etc.)
Petroleum Mfg	Facilities primarily dedicated to the refining of petroleum products
Plastic and Rubber Mfg	Facilities involved in the manufacture of plastic, resin, synthetic rubber, and rubber products
Pulp, Paper, and Wood Products Mfg	Paper, pulp, and paper-product mills and associated manufacturing
	Sawmills, veneer, and plywood manufacturing and other wood product manufacturing facilities
Agriculture	Agricultural facilities and operations for farming, vineyards, greenhouses, etc.

Potential Study Segment	Example of Industry Types
Other Industrial	All industrial facilities not specified above (for example, construction, textile manufacturing, apparel, machinery, furniture, toy manufacturing, printing, etc.)
Water & Wastewater Treatment	Water treatment across four sectors, including wastewater treatment plants (WWTP), drinking water treatment plants, wastewater pumping stations (WW Pumping) and drinking water pumping stations (DW Pumping)

Source: Navigant analysis

Electric Industrial Methodology

For all segments excluding agriculture and water/wastewater treatment, the IESO provided Navigant with consumption by zone, segment and end use. For the agriculture and water/wastewater treatment segments, the IESO provided Navigant with consumption by zone. End use allocation factors were developed to disaggregate the consumption in these segments into end use level data.

For the agriculture segment, end use allocation factors were developed by averaging values from two recent Canadian potential studies in other provinces. Both potential studies were conducted within the past five years. For the water/wastewater treatment segment, end use allocation factors were derived from internal research prepared for the IESO.[91]

Table A-7 shows the allocation factors developed for both segments.

Table A-7. Industrial End Use Allocation Factors (Electric)

End Use	Agriculture	Water & Wastewater Treatment
Compressed Air	9%	0%
Lighting	28%	1%
Motors - Fans/Blowers	12%	26%
Motors - Pumps	21%	61%
Motors - Other	1%	5%
Process Cooling	9%	0%
HVAC	16%	0%
Process Heating (Direct)	0%	0%
Process Heating (Water/Steam)	0%	0%
Other Process	4%	8%
Total	**100%**	**100%**

Source: Navigant analysis

Total consumption, by zone, segment, and end use for these two segments were calculated by multiplying segment-level consumption with the allocation factors shown above.

---

[91] Posterity Group - Market Characterisation & Conservation Potential for Ontario's Drinking Water & Wastewater Treatment Plants (2018)

Natural Gas Industrial Methodology

Navigant received base year natural gas consumption by segment from the natural gas utilities. Zone-level and end use breakdowns of segment consumption were not provided.

Geographic and Segment Mapping

The data provided by Enbridge Gas included consumption for a utilities segment. Discussions with Enbridge Gas revealed that consumption in this segment could be attributed to district heating consumption used by hospitals, large office buildings, and pulp and paper mills. Enbridge Gas staff provided Navigant with the base year distribution of consumption within this segment across the three relevant potential study segments: 24.7% hospitals, 30.9% large office, and 44.4% pulp, paper, and wood products.

Consumption data received from Enbridge did not contain zonal-level data. To map segment-level data to IESO zones, Navigant assumed that the proportion of industrial natural gas consumption across zones would mirror the proportion of industrial electricity consumption across zones. Navigant used the segment-level distribution of electricity consumption across zones to allocate Enbridge's base year natural gas consumption (by segment) across zones.

End Use Mapping

To disaggregate by end use, Navigant developed end use allocation factors from several sources. Navigant's preferred source for these was the Energy Information Administration (EIA) 2014 Manufacturing Energy Consumption Survey (MECS).[92] The MECS database provides natural gas consumption by end use and NAICS code.[93] Navigant mapped nine of the 14 potential study industrial segments to a NAICS code included in the MECS database to develop the end use allocation factors. This breakdown is shown in Table A-8.

Table A-8. Industrial Natural Gas Allocation Factor Mapping (MECS)

Potential Study Segment	MECS Code (#)	MECs Code (Name)
Chemicals Mfg.	325	Chemicals
Fabricated Metals Mfg.	332	Fabricated Metal Products
Primary Metals Mfg.	331	Primary Metals
Transportation and Machinery Mfg.	336	Transportation Equipment
Nonmetallic Minerals Product Mfg.	327	Nonmetallic Mineral Products
Food and Beverage Mfg.	311/312	Food / Beverage and Tobacco Products
Petroleum Mfg.	324	Petroleum and Coal Products
Plastic and Rubber Mfg.	326	Plastics and Rubber Products
Pulp, Paper and Wood Products Mfg.	321/322	Wood Products / Paper

Source: Navigant analysis

---

[92] U.S. Energy Information Administration, Manufacturing Energy Consumption Survey (MECs). Available: https://www.eia.gov/consumption/manufacturing/

[93] Based on feedback from representatives of the two natural gas utilities, the Machine Drive end use included in the MECS database was excluded when developing end use allocation factors.

The remaining segment allocation factors were derived from two previous Canadian potential studies. Table A-9 shows the total allocation factors used in the analysis.

Table A-9. Industrial Natural Gas Allocation Factors

Segment	HVAC	Process Cooling	Process Heating (Direct)	Other Process	Process Heating (Water/Steam)
Agriculture	50.0%	0.0%	0.0%	0.0%	50.0%
Chemicals Mfg.	4.1%	1.3%	60.0%	6.3%	28.3%
Fabricated Metals Mfg.	27.8%	0.0%	68.4%	1.3%	2.5%
Food and Beverage Mfg.	9.2%	0.8%	41.7%	6.9%	41.5%
Mining, Quarrying and Oil & Gas Extraction	8.3%	0.0%	27.9%	58.2%	5.7%
Nonmetallic Minerals Product Mfg.	6.8%	0.8%	90.2%	1.5%	0.8%
Other Industrial	49.8%	0.0%	20.5%	0.0%	29.7%
Petroleum Mfg.	0.7%	0.1%	79.4%	4.2%	15.6%
Plastic and Rubber Mfg.	31.7%	0.0%	34.9%	1.6%	31.7%
Primary Metals Mfg.	7.0%	0.9%	80.4%	7.7%	4.0%
Pulp, Paper, and Wood Products Mfg.	10.0%	0.0%	67.1%	3.2%	19.6%
Transportation and Machinery Mfg.	37.3%	0.0%	43.7%	5.6%	13.5%
Water & Wastewater Treatment	94.1%	0.0%	5.9%	0.0%	0.0%

Source: Navigant analysis

Total consumption is calculated at the zone and end use level by multiplying the segment-level consumption with the allocation factors shown above.

A.3 Results (Expanded)[94]

This section of the base year disaggregation appendix provides additional results for the residential and commercial sectors. In this section, results displaying energy intensities by segment and end use are provided. The industrial sector is not included in this section there is no stock for this sector.

A.3.1 Residential

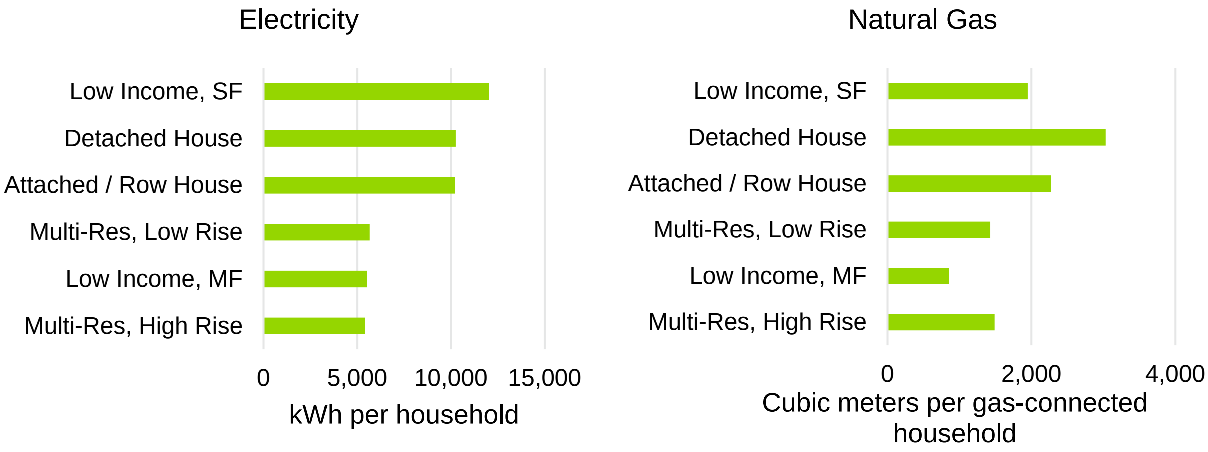
Figure A-1 shows electricity and natural gas intensities for each segment. Electricity intensities presented are calculated using the floor space associated with all households in IESO's dataset in the denominator. However, for natural gas intensity values, only the building space associated with natural gas-connected households was included. The resulting natural gas intensities therefore show natural gas consumption per m^3 for the average natural gas-connected household or business. Industrial intensities are not

---

[94] No energy intensity was estimated for the industrial sector. There is a large variety of processes, building types and building configurations, which make industrial floor space inadequate for developing end use intensities. Alternate denominators were investigated but ruled out due to lack of data and/or inapplicability to all industrial segments.

presented here as industrial energy use is driven primarily by production rather than floor space so this metric is not relevant to the industrial sector.

Figure A-1. Residential Energy Intensity by Segment, Province



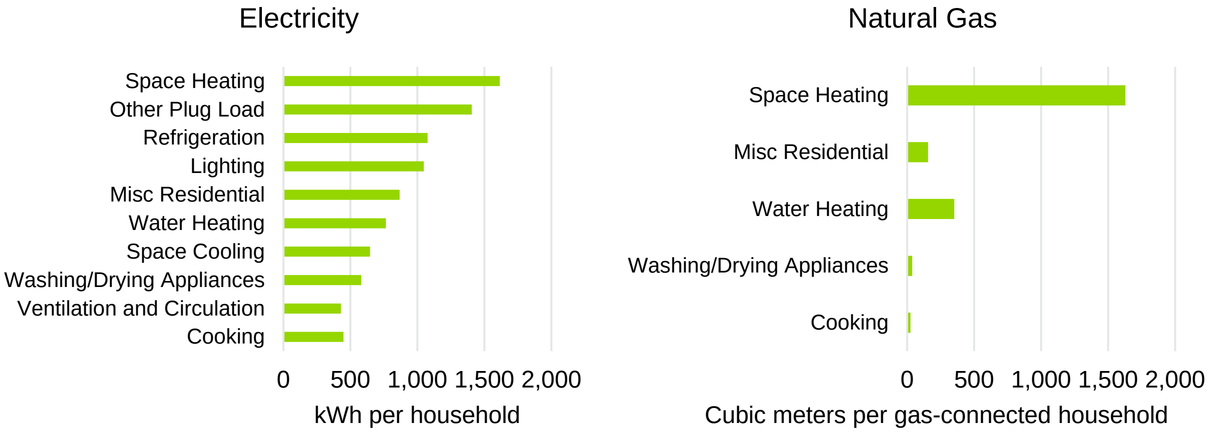
Source: Navigant analysis

Electricity energy intensity is highest for single-family households, including the segments low income, SF, detached house, and attached/row house. Natural gas energy intensities are highest for these segments as well, with detached house and attached/row house having larger intensities than the low income, SF segment.

As described previously, EUIs were adjusted for low income segments for both fuel types to account for the fact (documented in the REUS) that low income homes are more likely than non-low income homes to use electricity as their primary space heating fuel. It is this finding (and adjustment) that drives the result that while the electric energy intensity of the low income, SF segment is higher than that of the other (non-low income) single-family segments, the natural gas energy intensity of the Low Income SF segment is *lower* than that of the other (non-low income) single-family segments. A driver for this result may be geographic distribution of low income households, a higher proportion of which may be located in rural areas without access to natural gas.

Figure A-2 shows the residential end use energy intensity for both electricity and natural gas.

Figure A-2. Residential Energy Intensity by End Use, Province

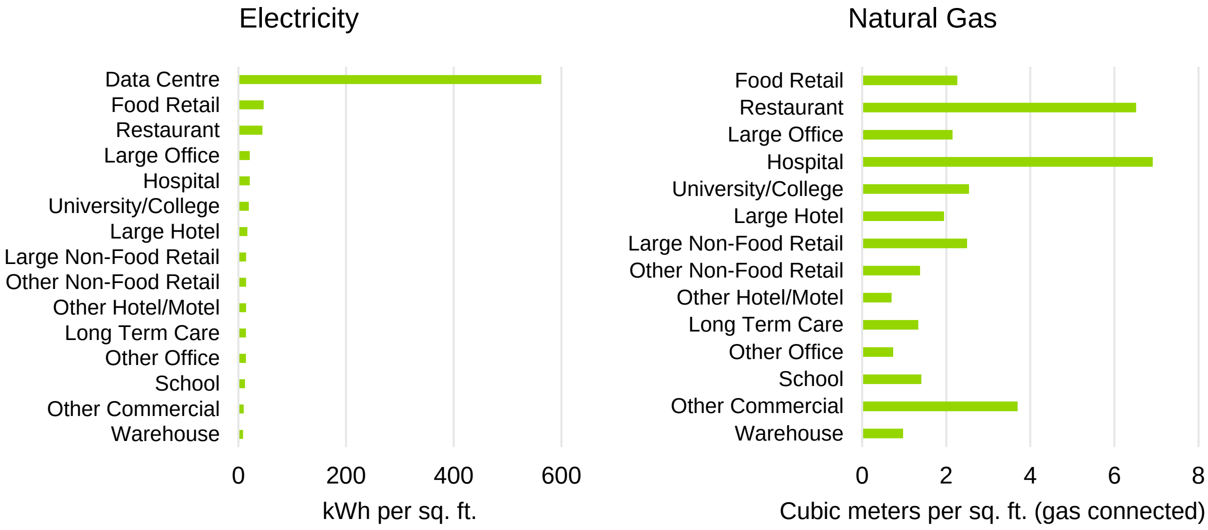


Source: Navigant analysis

A.3.2 Commercial

Figure A-3 provides the commercial energy intensity by segment for both natural gas and electricity.

Figure A-3. Commercial Energy Intensity by Segment, Province



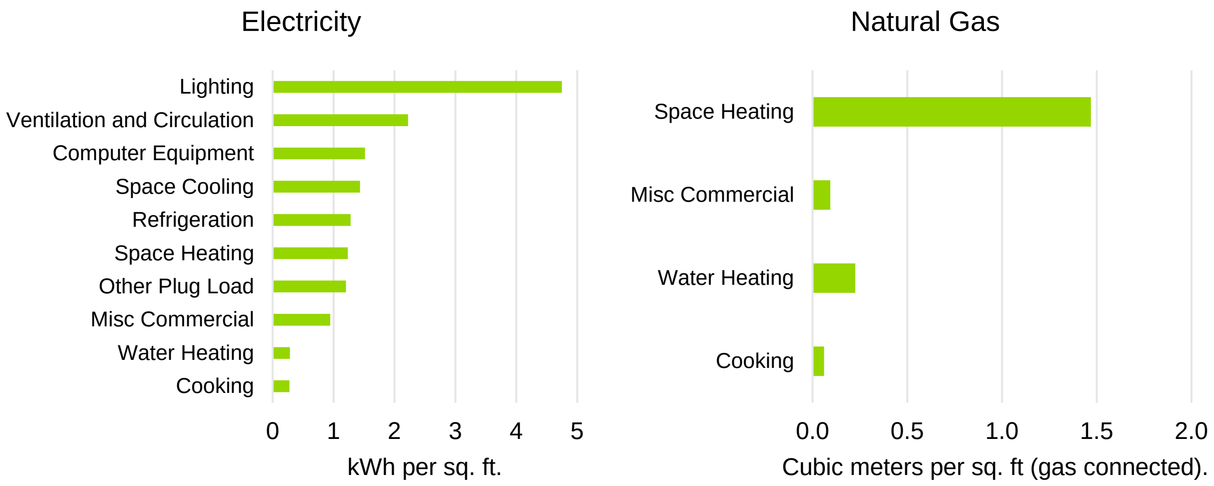
Source: Navigant analysis

The highest energy intensities across electric segments belong to data centres, restaurants, and food retail. For natural gas segments, the highest energy intensities belong to the hospital, restaurant, and other commercial segments.

Large discrepancies across fuel types exist for the hospital and food retail segments, but these reflect the disparity in fuel end uses; hospitals use a great deal more natural gas than they do electricity (for space and water heating, in particular), whereas food retail segment end use consumption is more concentrated in the refrigeration (electric only) than the cooking (typically natural gas) end use.

Figure A-4 provides the end use energy intensities by fuel for the commercial sector.

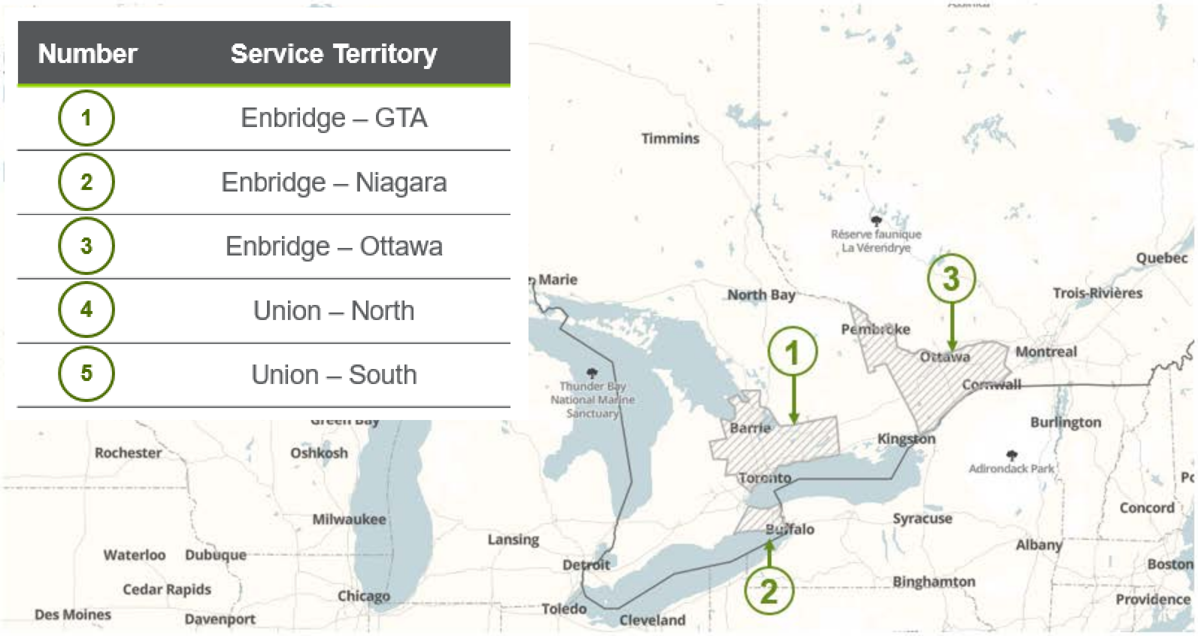
Figure A-4. Commercial Energy Intensity by End Use, Province



Source: Navigant analysis

This chart is, as expected, very similar to Figure 2-11. Electricity energy intensity in the commercial sector is highest for the lighting end use. Natural gas energy intensity is highest for the space heating end use.

A.4 Definition of Natural Gas Regions



Number	Service Territory
1	Enbridge – GTA
2	Enbridge – Niagara
3	Enbridge – Ottawa
4	Union – North
5	Union – South

Source: Navigant analysis

Appendix B. REFERENCE FORECAST

B.1 Data Sources

Table B-1 provides a comprehensive summary of the data sources used by Navigant throughout the reference forecast task. Note that the data sources identified indicate the organisation that provided the data, but not necessarily the organisation that generated the data.

Table B-1. Data Sources Used

Data Type	Data Source	Workbook(s) Destination	Description of Data
Forecast Electricity Consumption	IESO	**Electricity:** Residential, Commercial, Industrial	kWh consumption for all 10 IESO zones, disaggregated by IESO segment and end use, from 2018 to 2040
Forecast Natural Gas Consumption	Natural Gas Utilities	**Gas:** Residential, Commercial, Industrial	m^3 consumption for all utility natural gas regions, at sector-level, from 2018 to 2028
Housing Forecast[95]	IESO	**Electricity**: Residential **Gas**: Residential	Residential households, by IESO segment and IESO zone, from 2018 to 2040
Commercial Floor Space Forecast[96]	IESO	**Electricity**: Commercial **Gas**: Commercial	Commercial square footage, by IESO segment and IESO zone, from 2018 to 2040
Forecast Greenhouse Natural Gas Consumption	Union Gas	**Gas**: Industrial	Forecast of greenhouse-specific consumption in West IESO zone from 2018 to 2028
Forecast Greenhouse Electricity Consumption	IESO	**Electricity:** Industrial	Forecast of greenhouse-specific consumption (extrapolated from Agriculture segment) in West IESO zone from 2018 to 2028
Forecast Residential Water Heating Consumption	IESO	**Gas**: Residential	Forecast of water heating load, by segment and IESO zone, from 2018 to 2040, caused by fuel switching from electricity to natural gas

Source: Navigant analysis

B.2 Detailed Methodology

This section of the reference forecast appendix provides a more detailed description of the approach used by Navigant to develop the forecast used for this potential study. It is divided into following sub-sections:

1. Residential
2. Commercial

---

[95] The IESO purchases the household forecast from an external vendor.

[96] The IESO purchases the commercial floor space forecast from an external vendor.

3. Industrial

Each of these sub-sections describes the approach common to both fuels and then provides additional detail regarding specifics of the electricity disaggregation; this is followed by specifics of the natural gas disaggregation.

B.2.1 Residential

Both electricity and natural gas forecasts required a stock of households by segment and IESO zone. The IESO provided Navigant with a household forecast, with segments defined by the IESO for the reference forecast period. To align with the segments defined for the potential study, the household forecast needed to be disaggregated to include the two low income segments (single-family and multifamily) while ensuring that the total stock forecast aligns with what was originally provided. Navigant assumed that the percent of low income households (by IESO zone and segment group) that was used in the base year would remain constant throughout the forecast period. This allowed Navigant to modify the IESO's forecast of housing stock to match the potential study-defined segments. Total housing stock, by segment and year, is shown in Figure B-3 in Section B.3.1.

Electricity Residential Methodology

Navigant received a forecast of residential electricity consumption by IESO zone, segment and end use, from 2018 to 2038 from the IESO. This forecast did not include the two low income segments defined for this potential study. Navigant mapped the segments and end uses defined by the IESO to the segments and end uses defined for this potential study.

Navigant began by calculating end use intensity factors (EUIs) for each year of the forecast, which is calculated as the division of the consumption forecast (kWh) by the household forecast (households). To align with the base year disaggregation task, the IESO's 2018 REUS was used to differentiate the low income and non-low income energy intensities for the water heating, space heating, and space cooling end use, using the same methodology described for the BYD.

The adjusted EUIs were multiplied by the housing stock to determine uncalibrated consumption, by segment, end use and IESO zone. To ensure that the total consumption aligns with the sectoral forecast provided by the IESO, a calibration step was undertaken. The calibration process ensures that the final outputs (after all adjustments have been made) do not differ from the forecast provided by the IESO.

Natural Gas Residential Methodology

Navigant received a forecast of residential natural gas consumption from the natural gas utilities. The forecast was at the sector-level and needed to be disaggregated down to the segment and end use level. Additionally, the natural gas utilities were only able to provide a 10-year forecast of natural gas consumption (2018-2028). To extrapolate the forecast out to 2038, Navigant calculated the individual compound annual growth rate for each utility, using the 10-year forecast provided.

As the natural gas utilities define customers based on rate class, some of the segments in each sector did not align with the segments defined for this potential study. For example, the natural gas utilities define multifamily dwellings as a commercial building, while they were classified as residential dwellings in this potential study. In the BYD task, Navigant shifted this consumption into the residential sector. For the reference forecast, Navigant calculated a rate class adjustment, which was used to account for this shift in consumption, using data from the BYD. For the residential sector, the rate class adjustment increased total consumption in each year by 20%.

The next task was to modify the IESO's forecast of households to develop a forecast of natural gas-connected households. For the reference forecast, Navigant used the ratio of natural gas-connected households in the BYD task (percent of natural gas-connected households by IESO zone and segment group). This approach implicitly assumes that the percent of natural gas-connected households does not change over the reference forecast period, although the total number of natural gas-connected households will increase proportionally to the household forecast. Total natural gas-connected stock is shown in Figure B-4 in Section B.3.2 below.

To disaggregate the sector-level forecast down to the segment and end use level, Navigant multiplied the base year EUIs (2017) by the natural gas-connected housing forecast to calculate consumption over the forecast period. This resulted in an uncalibrated forecast of consumption by segment and end use for each IESO zone. Navigant calculated the percent of annual sectoral consumption that each combination of zone, segment and end use accounted for in this uncalibrated forecast. To calculate final calibrated consumption, Navigant multiplied each of these percentages by the sector-level forecast received from the natural gas utilities.

An additional adjustment was made for water heating based on annual fuel switching (electricity to natural gas) assumptions provided by the IESO. Navigant assumed that this load is already included in the natural gas utilities' sectoral forecast and hence modified the allocation of load. Navigant removed this consumption from the total sectoral value provided by the natural gas utilities, and once the load was disaggregated by segment and end use, reintroduced the fuel switching related water heating load provided. This ensures that the load is correctly attributed to the water heating and is not double-counted in the forecast.

B.2.2 Commercial

Both electricity and natural gas forecasts required a stock of commercial floor space by segment and IESO zone. The IESO provided Navigant with a forecast of commercial floor space, with segments defined by the IESO. As with the BYD task, all segments mapped one-to-one, excluding the other commercial segment, which includes data centre floor space. The IESO provided Navigant with total data centre floor space by IESO zone in 2016 and 2046. Navigant used the compound annual growth rate to calculate the floor space, by zone, in each year. This floor space was then subtracted from the other commercial floor space, such that the total floor space matched the forecast provided by the IESO. Total floor space, by year and segment, is shown in Figure B-7.

Electricity Commercial Methodology

Navigant received a forecast of commercial electricity consumption, by IESO zone, segment and end use and mapped the segments and end uses defined by the IESO to those defined for this potential study.

Like the residential forecast, Navigant began by calculating end use intensity factors (EUIs) for each year of the forecast, which are calculated as the division of the consumption forecast (kWh) by the commercial floor space forecast.[97] The adjusted EUIs were multiplied by the housing stock to determine uncalibrated consumption, by segment, end use and IESO zone. To ensure that the total consumption aligns with the sectoral forecast provided by the IESO, a calibration step was undertaken.

As electricity consumption for the data centre segment was not explicitly included in the IESO's forecast, but was included in the other commercial segment), Navigant multiplied the data centre floor space with the base year EUIs to determine data centre-specific consumption. This consumption was then subtracted from the other commercial segment to ensure that the sectoral forecast matches that provided by the IESO.

---

[97] The EUIs are also required by the model, which calculates potential.

Natural Gas Commercial Methodology

Navigant received a forecast of commercial natural gas consumption from the natural gas utilities. The forecast provided by the natural gas utilities was at the sector-level and had to be disaggregated down to the segment and end use level. Additionally, the natural gas utilities were only able to provide a 10-year forecast of natural gas consumption (2018-2028). To extrapolate the forecast out to 2038, Navigant calculated the individual compound growth rate for each utility using the 10-year forecast provided.[98]

As the natural gas utilities define customers based on rate class, some of the segments in each sector do not align with the segments defined for this potential study. For the commercial sector, the rate class adjustment decreased total consumption in each year by 20%, which accounts for the removal of consumption in multi-residential buildings which was incorporated in the residential sector and the addition of some large commercial and industrial customers into the commercial segment from the industrial segment.

The next task was to modify the IESO’s forecast of commercial floor space to only include natural gas-connected premises. For the reference forecast, Navigant used the ratio of natural gas-connected floor space from the base year (percent of natural gas-connected floor space by IESO zone and segment) and assumed it to remain constant for the reference forecast period. Total natural gas-connected floor space, by year and segment, is shown in Figure B-8.

To disaggregate the sector-level forecast down to the segment and end use level, Navigant used the base year EUIs (2017) multiplied by the natural gas-connected floor space forecast. This resulted in an uncalibrated forecast of consumption by segment, end use and IESO zone. Navigant calculated the percent of annual sectoral consumption for each combination of zone, segment and end use accounted for in this uncalibrated forecast. To calculate the final calibrated consumption, Navigant multiplied each of these percentages by the sector-level forecast received from the natural gas utilities.

B.2.3 Industrial

No stock forecast was used for the industrial sector as is in the BYD task. The absence of stock means that no intensities were developed for this sector.

Electricity Industrial Methodology

Navigant received a forecast of industrial electricity consumption, by IESO zone, segment and end use, and mapped the segments and end uses defined by the IESO to the segments and end uses defined for this potential study. This forecast did not include the water and wastewater treatment segment, nor the agriculture segment.

The water and wastewater segment was received in a separate forecast by year and zone and was not disaggregated by end use. Navigant used the end use allocation factors (percentage of segment-level consumption by end use) from the base year to disaggregate the segment forecast down to the end use level.

The agriculture segment was also received in a separate forecast by year and zone. For the West zone, the IESO separated consumption in the segment that was allocated to greenhouses as they are forecast to have a large increase in consumption in the West region over the reference forecast period. As this sub-segment has a different end use profile than the agriculture segment, the two were separated.

---

[98] Navigant discussed this approach with the natural gas utilities and the OEB and obtained consensus as no additional information was available.

The agriculture load (without the greenhouse sub-segment) was disaggregated into end use consumption using the end use allocation factors from the BYD task. The greenhouse-specific consumption was disaggregated into its end uses using end use allocation factors developed from three external sources.[99,100,101]

Natural Gas Industrial Methodology

Navigant received a forecast of industrial natural gas consumption from the natural gas utilities. The forecast provided by the natural gas utilities was at the sector-level and had to be disaggregated down to the segment and end use level. Additionally, the natural gas utilities were only able to provide a 10-year forecast of natural gas consumption (2018-2028). To extrapolate the forecast out to 2038, Navigant calculated the individual compound growth rate for each utility from 2022 to 2028, using the 10-year forecast provided.[102]

As the natural gas utilities define customers based on rate class, some of the segments in each sector do not align with the defined segments for this potential study. For the industrial sector, the rate class adjustment decreased total consumption in each year by a factor of 0.95, which accounts for the removal of some large commercial and industrial customers (re-allocated to the commercial sector in the BYD task).

Union provided Navigant with a forecast (from 2018 to 2028) of natural gas consumption specific to greenhouses in the West zone. As with electricity, natural gas consumption in the agriculture segment is forecast to increase due to growth in the greenhouse industry. As with the electricity forecast, this sector-level consumption was disaggregated into end uses using the same sources.

To disaggregate sectoral forecast down to the segment and end use level, the sectoral value was multiplied by allocation factors developed by Navigant. These allocation factors, which were held constant for the reference forecast period, were calculated using the sales by segment and end use from the base year as a percentage of the total annual sectoral consumption, effectively holding the allocation factors constant over the reference forecast period.

B.3 Results (Expanded)

This section of the reference forecast appendix provides additional results for the residential and commercial sectors. In this section, results displaying energy intensities by segment and end use are provided, as well as forecasts of stock and natural gas-connected stock. The industrial sector is not included in this section as no stock is forecast for this sector.

---

[99] Trends and Observations of Energy Use in the Cannabis Industry, https://aceee.org/files/proceedings/2017/data/polopoly_fs/1.3687880.1501159058!/fileserver/file/790266/filename/0036_0053_000046.pdf

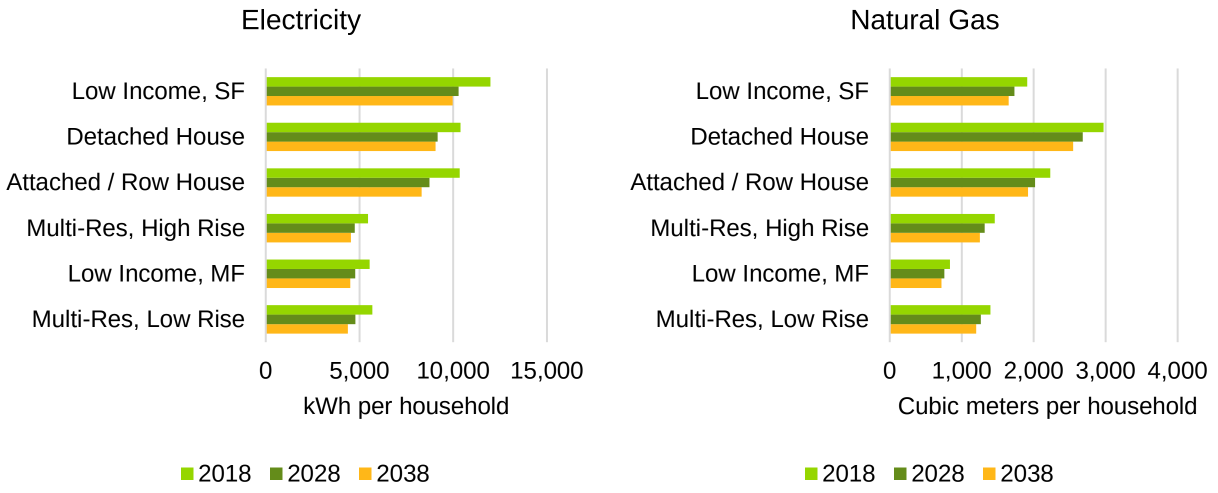
[100] Harvesting Energy Savings in Indoor Agriculture Facilities, https://www.esource.com/tas-f-18/harvesting-energy-savings-indoor-agriculture-facilities

[101] Boulder County Energy Impact Offset Fund (BCEIOF) Demand Side Management Study, https://assets.bouldercounty.org/wp-content/uploads/2018/04/BCEIOF-DSM-Study-Phase-1.pdf

[102] Navigant discussed this approach with the natural gas utilities and the OEB and obtained consensus as no additional information was available.

B.3.1 Residential

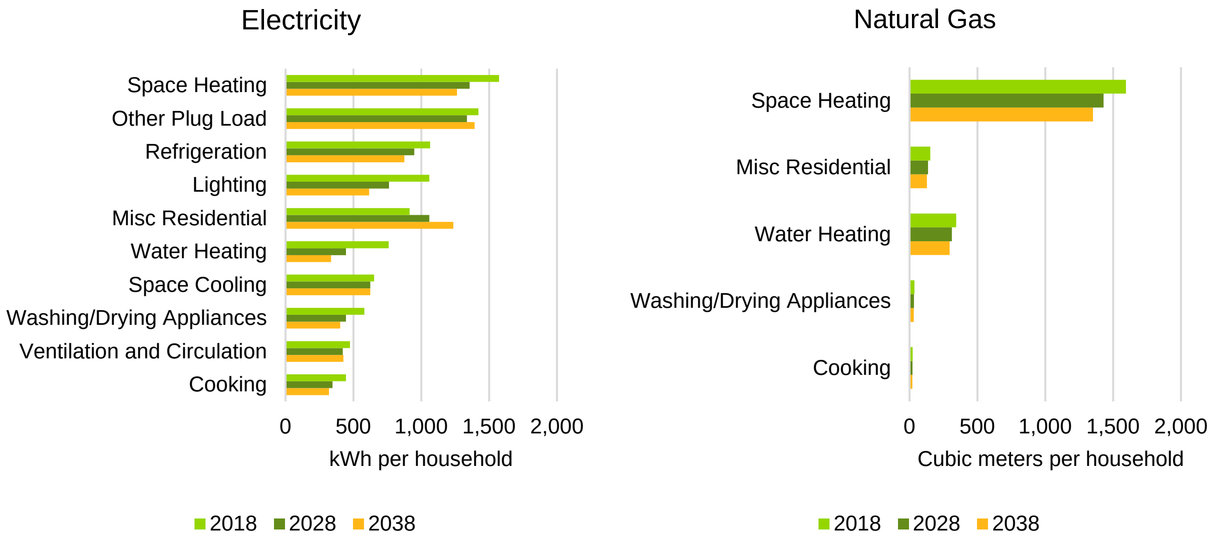
Figure B-1. Residential Energy Intensity by Segment (Electricity and Natural Gas)



Sources: Navigant analysis, IESO, Enbridge Gas, Union Gas

Figure B-1 shows the change in energy intensity per residential segment (consumption per household, per year) from 2018 to 2038. Across both fuel types, every segment sees a decrease in energy intensity across the forecast period. Decreases in energy intensities are driven by forecast increases in equipment efficiencies across various end uses, such as water heating and space heating, shown below.

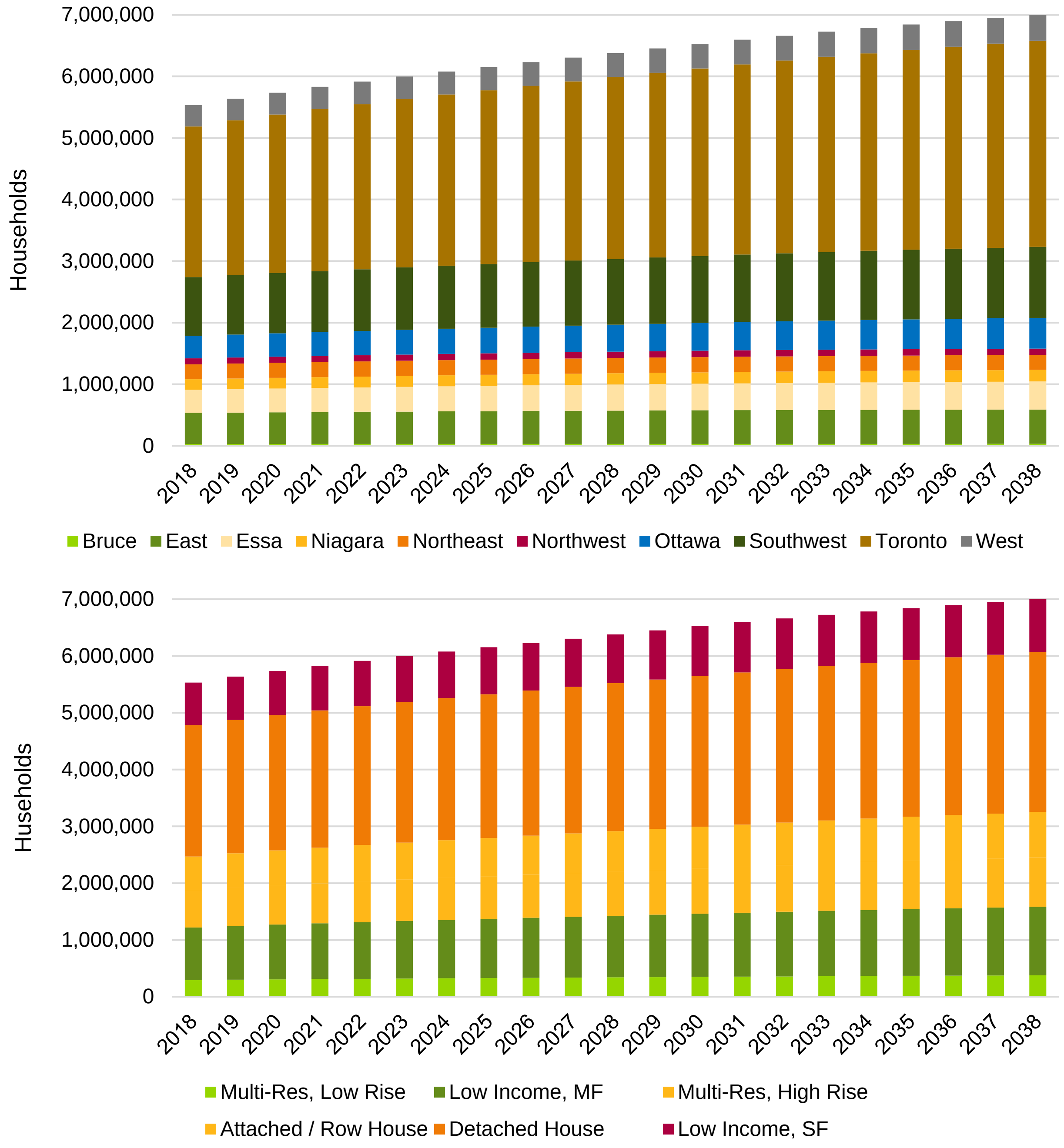
Figure B-2. Residential Energy Intensity by End Use (Electricity and Natural Gas)



Sources: Navigant analysis, IESO, Enbridge Gas, Union Gas

Figure B-2 shows the change in energy intensity by end use (consumption per household, per year) from 2018 to 2038. The general trend across all end uses for both fuels is a decrease in consumption per household throughout the forecast period which is driven by efficiency gains. The main exception is electric miscellaneous residential which shows an increase in energy intensity and the corresponding increase in consumption shown in Figure B-3.

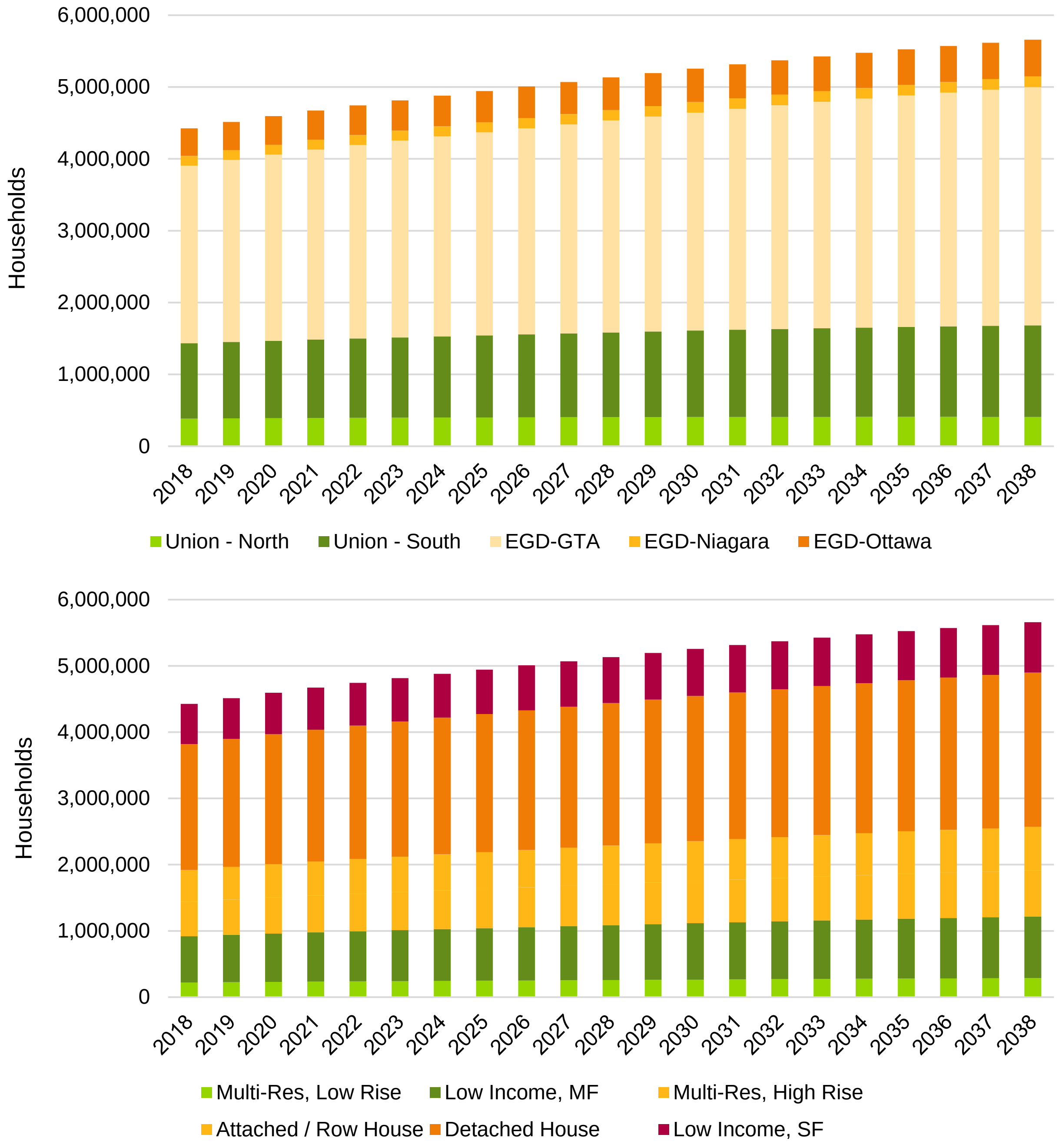
Figure B-3. Residential Stock Forecast (Households) by IESO Zone and Segment



Sources: Navigant analysis, IESO, Enbridge Gas, Union Gas

Housing stock in the residential sector is forecast to increase from 5.5 million households to 7 million households from 2018 to 2038. Only one IESO zone (Northeast) is forecast to reduce in housing stock over the reference forecast period, decreasing <1%. The Ottawa and Toronto zones are forecast to increase the greatest amount, each growing 37% from 2018 to 2038. These zones contain large metropolitan centres which are more densely populated compared to the other zones. All segments are forecast to increase in stock by 2038, with the attached / row house segment increasing the greatest amount (35%). The detached house segment is forecast to increase at the slowest rate, growing 22% by 2038.

Figure B-4. Residential Stock Forecast (Natural Gas-Connected Households) by Natural Gas Region and Segment



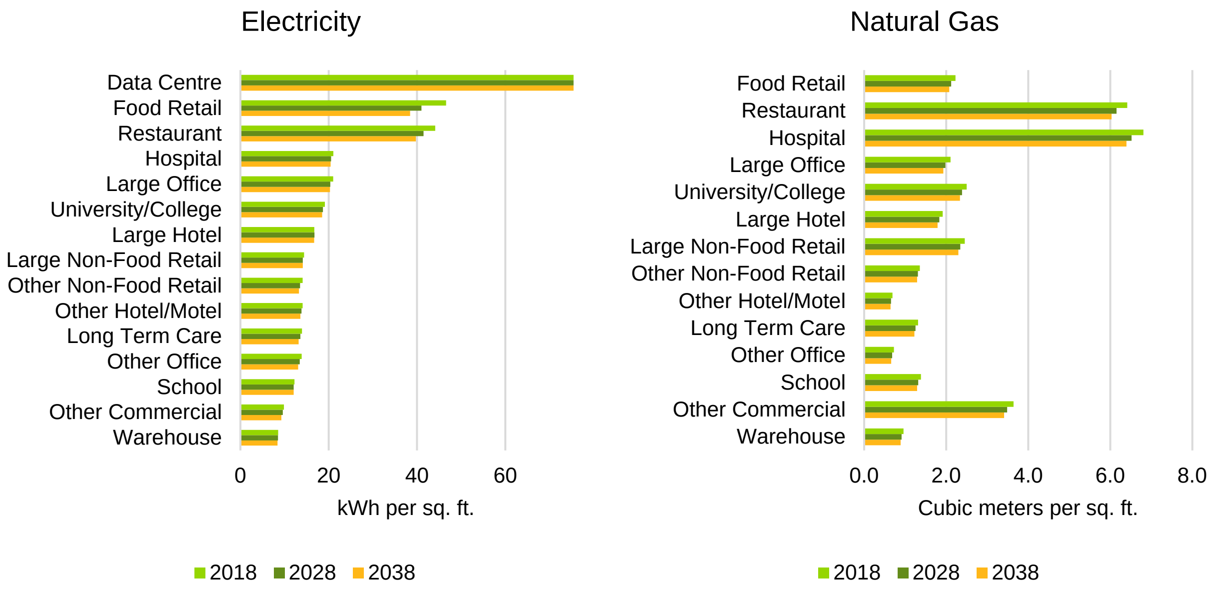
EGD = Enbridge

Sources: Navigant analysis, IESO, Enbridge Gas, Union Gas

Natural gas-connected housing stock in the residential sector is forecast to increase from 4.4 million households to 5.7 million households from 2018 to 2038. It is important to note that the percent of natural gas-connected households for each region was obtained from the BYD and was held constant for the reference forecast period. Hence the overall growth trends are driven simply by the forecast growth for each zone. All the natural gas regions are forecast to increase in housing stock over the forecast period. Similar to electricity, the EGD – GTA and EGD – Ottawa zones are forecast to increase the greatest amount over the reference period, increasing 34% and 33% respectively. All segments are forecast to increase in natural gas-connected stock by 2038, with the attached/row house segment increasing the greatest amount (37%). The detached house segment is forecast to increase at the slowest rate, growing 23% by 2038.

B.3.2 Commercial

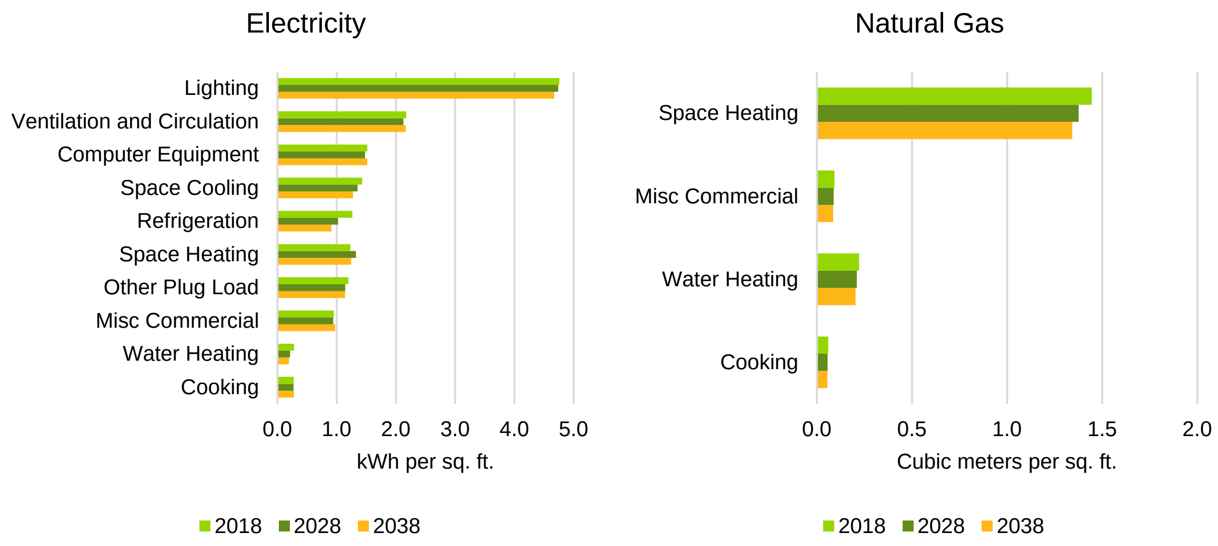
Figure B-5. Commercial Energy Intensity by Segment (Natural Gas and Electricity)



Sources: Navigant analysis, IESO, Enbridge Gas, Union Gas

Figure B-5 shows the change in energy intensity per commercial segment (consumption per square foot, per year) from 2018 to 2038. Similar to the residential sector, every segment sees a slight decrease in energy intensity across the forecast period driven by efficiency gains.

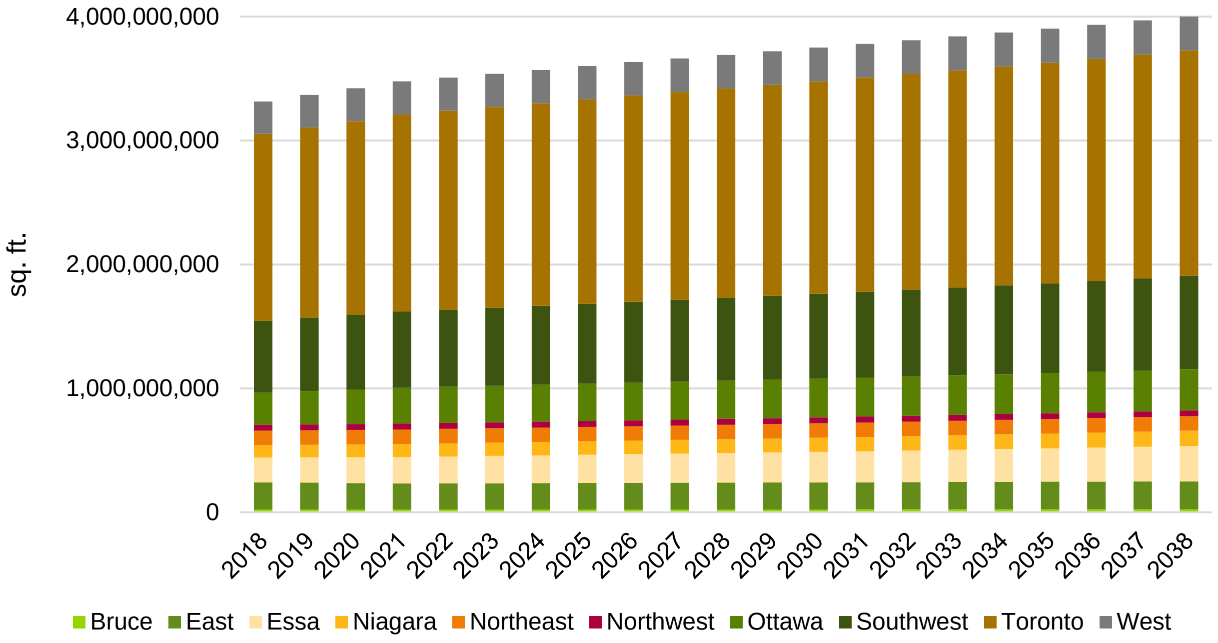
Figure B-6. Commercial Energy Intensity by End Use (Natural Gas and Electricity)

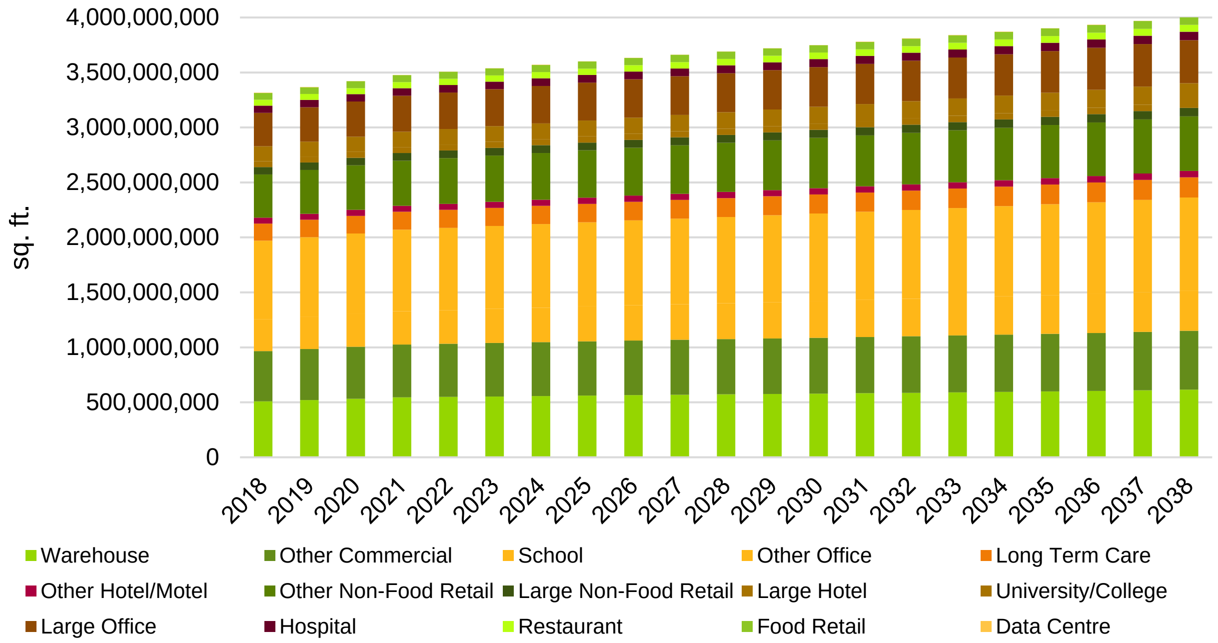


Sources: Navigant analysis, IESO, Enbridge Gas, Union Gas

Figure B-6 shows the change in energy intensity by end use (consumption per square foot, per year) from 2018 to 2038. The general trend is that of declining end use intensities with a few exceptions on the electricity side such as miscellaneous commercial.

Figure B-7. Commercial Stock Forecast (Square Footage) by IESO Zone and Segment

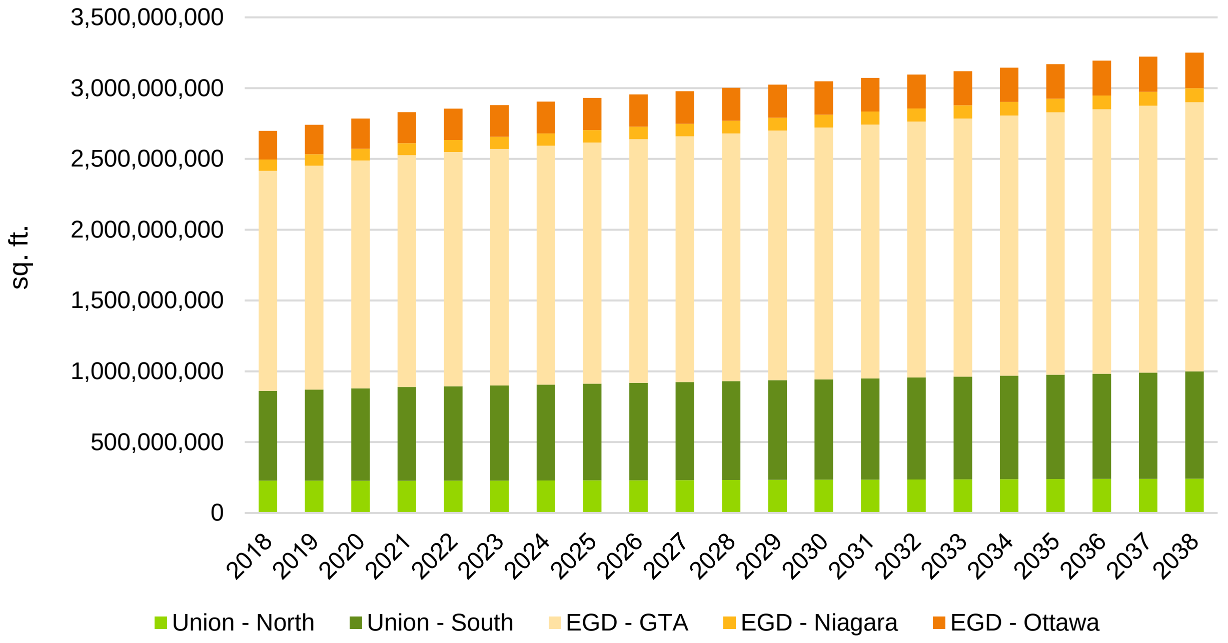


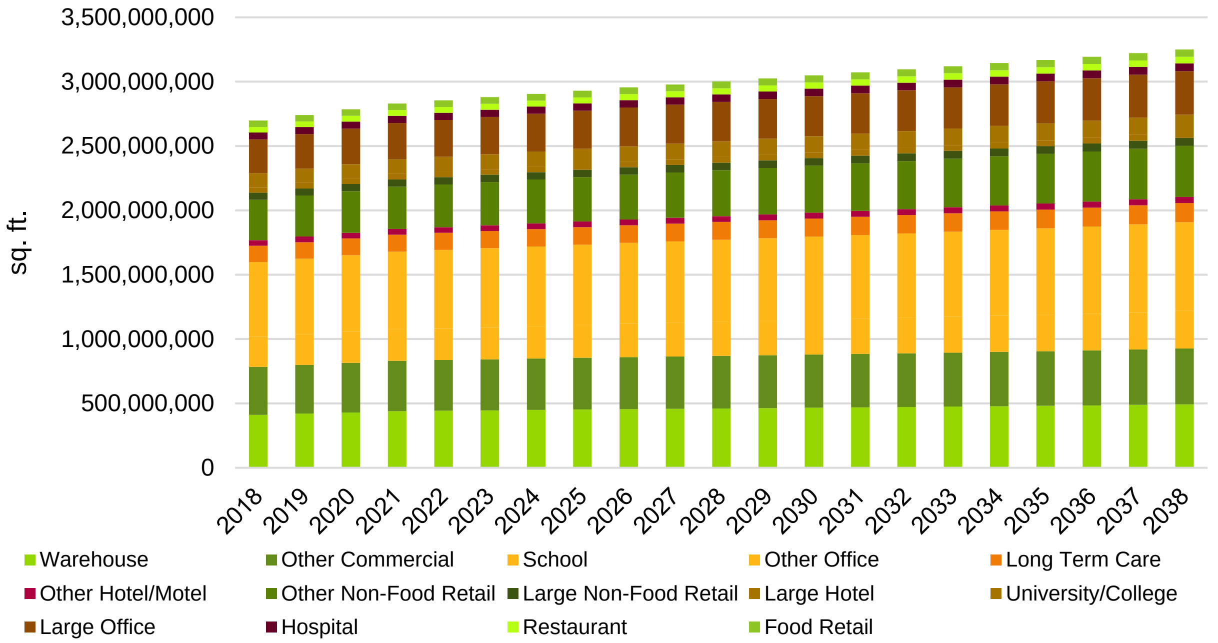


Sources: Navigant analysis, IESO, Enbridge Gas, Union Gas

Commercial square footage is forecast to increase from 3.3 billion square feet to 4.0 billion square feet from 2018 to 2038. The Northeast and Northwest zones do not experience growth over the forecast period. All zones, except for the Northeast and Northwest, experience some growth with Essa, Southwest and Ottawa seeing the most growth. All segments are forecast to increase in stock by 2038. The data centre and large office segments are forecast to increase the greatest amount, increasing 31% and 28% respectively by 2038. The other hotel/motel and large hotel segments increase the lowest amount, increasing 8% each by 2038.

Figure B-8. Commercial Stock Forecast (Natural Gas-Connected Square Footage) by Natural Gas Region and Segment





EGD = Enbridge

Sources: Navigant analysis, IESO, Enbridge Gas, Union Gas

Natural gas-connected commercial square footage is forecast to increase from 2.7 billion square feet to 3.2 billion square feet from 2018 to 2038. As with the residential sector, it is important to note that the percent of natural gas-connected commercial floor space for each region was obtained from the BYD and was held constant for the reference forecast period. Hence the overall growth trends are driven simply by the forecast growth for each zone. All the natural gas regions experience some growth with the EGD –

Ottawa, EGD – Niagara and EGD – Ottawa regions experiencing the most growth. All segments are forecast to increase in natural gas-connected stock by 2038. The large office and other non-food retail segments are forecast to increase the greatest amount, increasing 28% and 26%, respectively. The other hotel/motel and large hotel segments increase the lowest amount, increasing 9% each by 2038.

B.4 Compatibility Assessment – Additional Detail

This section of the reference forecast appendix provides additional details with regards to the assumptions used by the various forecasts and the comparisons that demonstrate that they share a broadly consistent view of the future and are hence compatible for the purpose of this potential study.

As mentioned in Section 3.2.1, given the different fuel types being forecast and the diversity in geographic service territories, differences in load forecast methodologies and their input assumptions are inevitable. Hence, it is imperative to note that forecast compatibility does not mean that a perfect alignment exists in forecast assumptions. There is cause for concern only where there is a material disconnect between overall assumptions regarding the state of the province for the duration of the reference forecast period.

This section is further divided into following sub-sections:

- Global Assumptions
- Sectoral Assumptions

It is important to note that since the compatibility assessment was completed, the IESO forecast has been updated and the IESO has confirmed that there are no major changes in assumptions that would alter the conclusions of the compatibility assessment.

B.4.1 Global Assumptions

All forecasts share a sufficiently consistent view of the future to regard the forecasts as compatible as demonstrated in Table B-2.

Table B-2. Global Assumptions Summary

	Enbridge	Union	IESO	Comments
Existing CDM/DSM (Persistence)	Embedded in historical trend	Embedded in historical trend	Explicitly accounted for	All forecasts account for historical CDM
Codes and Standards	Existing embedded in historical trend, new explicitly accounted for	Embedded in historical trend	New and existing explicitly accounted for	All forecasts account for codes and standards
Natural Conservation	Embedded in historical trend	Embedded in historical trend	Embedded in historical trend	Compatible
Carbon Pricing	Included	Included	IESO assumption not yet final but included	Difference in impact from differing carbon pricing assumptions very small

	Enbridge	Union	IESO	Comments
Fuel Switching	Embedded in historical trend	Embedded in historical trend.	Assumptions under development.	IESO assumptions likely to reflect historical trends. (i.e., almost certainly compatible)
Weather Effects	Weather Normalised	Weather Normalised	Weather Normalised	Compatible

Source: Navigant analysis

B.4.2 Sectoral Assumptions

All sectoral forecasts share a sufficiently consistent view of the future to regard the forecasts as compatible, as demonstrated in Table B-3.

Table B-3. Sectoral Assumptions Summary

	Enbridge	Union	IESO	Comments
Residential	Projected customer growth rate: 1.32%	Projected customer growth rate: 1.1%	Projected household growth rate: 1.43%	Compatible
Commercial	Employment forecast consistent with recent history (slightly optimistic)	Unemployment rate consistent with recent history (slightly optimistic)	Employment forecast consistent with recent history	Compatible
Industrial	Customer and segment specific assumptions	Customer and segment specific assumptions	Segment specific assumptions	Compatible

Source: Navigant analysis

Appendix C. MEASURE CHARACTERISATION

C.1 Detailed Methodology

This section provides the measure list, peak demand estimates, unit impacts for DR measures, sources for costs and savings and details of the industrial measures.

C.1.1 Measure List

This section contains the entire measure list used in the potential study by sector.

Table C-1. Residential Energy Efficiency Measure List

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Res | ENERGY STAR Clothes Dryer	ENERGY STAR Clothes Dryer	Standard Clothes Dryer	Washing/Drying Appliances	Electric & Natural Gas	ROB and NEW
Res | ENERGY STAR LED Specialty Bulbs	ENERGY STAR LED BULBS - SPECIALTY (3-way bulbs, candle bulbs, flood/reflector bulbs, globe bulbs)	Baseline mix (incandescent/halogen, CFL)	Lighting	Electric	ROB and NEW
Res | ENERGY STAR LED Bulbs General Purpose LEDs	ENERGY STAR LED BULBS - General Purpose LEDs	Baseline mix (incandescent/halogen, CFL)	Lighting	Electric	ROB and NEW
Res | LED Downlight	LED Downlight with Light Output >600 and <800 lumens or >800 lumens	75 W or 100 W Incandescent/CFL bulbs	Lighting	Electric	ROB and NEW
Res | Ductless Mini-Split Air Conditioner	Ductless Mini-Split Air Conditioner 16 SEER	Standard room A/C	Space Cooling	Electric	ROB and NEW
Res | Air Sealing	Performance improvement of 13 to 9 ACH50 or 9 to 7 ACH50 (ACH @ 50 Pa)	Air sealing performance of 13 ACH50/ 9 ACH50	Space Cooling and Heating	Electric & Natural Gas	RET Only
Res | Air Sealing	Performance improvement of 13 to 9 ACH50 or 9 to 7 ACH50 (ACH @ 50 Pa)	Air sealing performance of 13 ACH50/ 9 ACH50	Space Cooling and Heating	Electric & Natural Gas	RET Only
Res | Wall Insulation	Added Wall Insulation: Average values (R13, R19, R23, R29)	Average wall insulation: (R4)	Space Cooling and Heating	Electric & Natural Gas	RET Only
Res | Duct Sealing	Duct Sealing: 16.25% (CFM @25Pa) or 25% (CFM @25Pa)	Duct sealing performance of 25% or 38%	Space Cooling and Heating	Electric & Natural Gas	RET Only
Res | ENERGY STAR Room Air Conditioner	ENERGY STAR Room Air Conditioner - With or without Replacement (ENERGY STAR Qualified 6,000 – 12,000 Btu/hr)	Non-ENERGY STAR Room Air Conditioner	Space Cooling	Electric	ROB and NEW
Res | High Efficiency Condensing Furnace	High Efficiency Condensing Furnace AFUE 95% or greater	High Efficiency Furnace, AFUE 90	Space Heating	Natural Gas	ROB and NEW

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Res | Tankless Water Heater	Condensing or Non-condensing Tankless Water Heater	Storage Tank Water Heater	Water Heating	Electric & Natural Gas	ROB and NEW
Res | Smart Power Bar	Smart power bar TIER 2	No Power Bar	Other Plug Load	Electric	RET Only
Res | ENERGY STAR A Line, PAR, MR Lamps	ENERGY STAR A Line, PAR, MR Lamps	Baseline mix (incandescent/halogen, CFL)	Lighting	Electric	ROB and NEW
Res | ENERGY STAR Light Fixture	ENERGY STAR certified indoor LED light fixture - 1,2 3+ SOCKETS	Non-ENERGY STAR certified light fixture with weighted average of incandescent, halogen, linear fluorescent, and LED lighting	Lighting	Electric	ROB and NEW
Res | Adaptive Thermostat	Adaptive/Smart Thermostat	Programmable or Non-Programmable Thermostat	Space Cooling and Heating	Electric & Natural Gas	RET and NEW
Res | High Efficiency Fireplace with Pilotless Ignition	A new high efficiency fireplace with intermittent (pilotless) ignition: freestanding fireplace, Insert, Zero Clearance < 40 kBtu/h, Zero Clearance >= 40 kBtu/h	A typical Gas fireplace based on the median fireplace model	Space Heating	Natural Gas	ROB and NEW
Res | Heat Recovery Ventilator	Fan system with high efficiency heat/energy recovery ventilator (HRV)	Fan system without heat recovery	Ventilation and Circulation	Electric & Natural Gas	NEW Only
Res | Comprehensive Draft Proofing	Comprehensive Draft Proofing	No Insulation	Space Cooling and Heating	Natural Gas	RET Only
Res | Home Energy Reports	Social Benchmarking Info Access/Behaviour Modification: Home Energy Reports (6-8 reports mailed per year)	No report provided to customer	All	Electric & Natural Gas	NEW Only
Res | Home Energy Reports	Social Benchmarking Info Access/Behaviour Modification: Home Energy Reports (6-8 reports mailed per year)	No report provided to customer	All	Natural Gas	NEW Only
Res | Central Air Conditioner Maintenance	Central Air Conditioner Maintenance (10.4 SEER to 11 SEER)	No maintenance/tune-up	Space Cooling	Electric	RET Only
Res | ENERGY STAR Central Air Conditioner	ENERGY STAR Central Air Conditioner - SEER 16/18/20	SEER 15 Central Air Conditioner	Space Cooling	Electric	RET, ROB and NEW
Res | Ceiling Insulation	Ceiling Insulation: R-49 or R-60	Ceiling Insulation: R-5, R-20, R-30	Space Cooling and Heating	Electric & Natural Gas	RET Only
Res | Radiant Barrier	Radiant barrier on roof decking	No radiant barrier	Space Cooling and Heating	Electric	RET Only
Res | ENERGY STAR Air Source Heat Pump	ENERGY STAR Air Source Heat Pump (15 SEER / 8.5 hspf) or (16 SEER / 9.0 hspf)	ENERGY STAR Air Source Heat Pump (14 SEER / 7.1 hspf)	Space Cooling and Heating	Electric	ROB and NEW
Res | Ductless Mini-Split Heat Pump	Ductless Mini-Split Heat Pump (16 SEER / 9.0 hspf)	baseboard heat/room AC	Space Cooling and Heating	Electric	ROB and NEW
Res | Induction Cooking Stove Top	Induction Cooking Stove top	Standard Stove top	Cooking	Electric	ROB and NEW

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Res | Attic Insulation	Attic Insulation R-20 to R-40	No Insulation or R-10	Space Cooling and Heating	Electric & Natural Gas	RET Only
Res | Basement Wall Insulation	Basement Wall Insulation: R-10, R-12, R-15	Basement Wall Insulation: R-1 or R-3	Space Cooling and Heating	Electric & Natural Gas	RET Only
Res | High Efficiency Storage Water Heater	High Efficiency Storage Water Heaters	storage electric hot water heater	Water Heating	Electric & Natural Gas	ROB and NEW
Res | High Efficiency Storage Water Heater	Condensing High Efficiency Storage Water Heaters	Storage Gas water heater	Water Heating	Electric & Natural Gas	ROB and NEW
Res | Water Heater Temperature Setback	Water Heater Temperature Setback (from 130 to 120 degrees)	No temperature setback	Water Heating	Electric & Natural Gas	RET Only
Res | Networked/ Connected - Indoor LED Lamp	Networked/ Connected - Indoor LED Lamp	Baseline mix (incandescent/halogen, CFL)	Lighting	Electric	ROB and NEW
Res | Early Hot Water Heater Replacement	Early Hot Water Heater Replacement (0.67 EF)	Hot Water Heater (0.575 EF), Water Heater must still be useable for another 3 years and between 0.56 EF and 0.59 EF	Water Heating	Electric & Natural Gas	RET Only
Res | Drain Water Heat Recovery	Drain Water Heat Recovery Device/Ventilator	No heat recovery device/ventilator	Water Heating	Electric & Natural Gas	RET Only
Res | Minimise Hot and Warm Clothes Wash	Minimise Hot and Warm Clothes Wash to 25% of clothes washes with hot water (2,250 gallons, or 8,515 L, on average per year)	75% of clothes washes with hot water (6,750 gallons, or 25,550 L, on average per year)	Water Heating	Electric & Natural Gas	RET Only
Res | Networked/ Connected - Indoor LED Luminaire	Networked/ Connected - Indoor LED Luminaire	Incandescent/CFL Fixture	Lighting	Electric	ROB and NEW
Res | Smart Burners	SmartBurner Intelligent Cooking System 1250-2100 Wplate for electric stove (regular stove coils are replaced with smart burners)	Standard Wall Oven (electric stove with regular coils)	Cooking	Electric	ROB and NEW
Res | ENERGY STAR Torchiere	ENERGY STAR Torchiere	Standard torchiere	Lighting	Electric	ROB and NEW
Res | Heavy Duty Outdoor/Holiday Plug-in Timers	HEAVY DUTY PLUG-IN TIMERS (HOLIDAY/outdoor LIGHTING)	No holiday/outdoor lighting timer	Lighting	Electric	RET Only
Res | Lighting Motion Sensors, Timers, Dimmers	Indoor/Outdoor Motion Sensor/Dimmer Switch/Timers (Hard-Wired)	Conventional light fixtures with no control devices	Lighting	Electric	ROB and NEW
Res | Clothes Drying Racks	Indoor/Outdoor Clothes Drying Racks replacing a number of loads each week	Electric Clothes Dryer	Washing/Drying Appliances	Electric & Natural Gas	RET Only
Res | Clothes Drying Racks	Indoor/Outdoor Clothes Drying Racks replacing a number of loads each week	Gas Clothes Dryer	Washing/Drying Appliances	Electric & Natural Gas	RET Only

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Res | ENERGY STAR Dishwasher	ENERGY STAR Dishwasher	Standard Dishwasher	Washing/Drying Appliances	Electric	ROB and NEW
Res | ENERGY STAR Ceiling Fan/Lighting	ENERGY STAR qualified ceiling fan with or without light fixture	Conventional non-ENERGY STAR qualified ceiling fan with or without light fixture	Space Cooling	Electric	ROB and NEW
Res | Car Block Heater Timer	HEAVY DUTY PLUG-IN TIMERS Car Block Heater Timer	No timer on the car block heater	Other Plug Load	Electric	RET and NEW
Res | Air Source Heat Pump Maintenance	Air Source Heat Pump Maintenance (12.3 SEER/ 7.3 hspf) or (13 SEER / 7.7 hspf)	No maintenance, service, or tune-up	Space Cooling and Heating	Electric	RET Only
Res | Air Source Heat Pump	Central Air Source Heat Pump	baseboard heat/room AC	Space Cooling and Heating	Electric	ROB and NEW
Res | ENERGY STAR Ground Source Heat Pump	ENERGY STAR Ground Source Heat Pump (17.1 EER / 3.6 COP)	14 SEER air source heat pump	Space Cooling and Heating	Electric	ROB and NEW
Res | Furnace Whistle	Furnace Whistle - electric or gas heating and central AC	No furnace whistle on electric or gas furnace with electric forced air heating	Space Cooling and Heating	Electric	RET Only
Res | Window Film	Window Film (U=0.51, SHGC=0.24)	No window film	Space Cooling and Heating	Electric & Natural Gas	RET Only
Res | Variable Speed Pool Pump Motor	Dual or Variable Speed Pool Pump Motors	Single speed pool pump motor	Misc. Residential	Electric	RET Only
Res | ENERGY STAR Refrigerator	ENERGY STAR REFRIGERATOR (Qualified 15.5 - 16.9 cu ft) or (Qualified 17.0 - 18.4 cu ft) TIER 1,2,3	Standard Refrigerator	Refrigeration	Electric	ROB and NEW
Res | ENERGY STAR Freezer	ENERGY STAR FREEZER TIER 1,2,3	Standard Freezer	Refrigeration	Electric	ROB and NEW
Res | Refrigerator Recycling	Refrigerator Recycling with or without Replacement	No recycling	Refrigeration	Electric	RET Only
Res | Freezer Recycling	Freezer Recycling with or without Replacement (Retirement of non-primary freezers in homes with more than one freezer; Replacement unit assumed to be standard efficiency model if replaced)	No recycling	Refrigeration	Electric	RET Only
Res | Duct Insulation	Duct insulation R-8	Duct insulation R-0	Space Cooling and Heating	Electric & Natural Gas	RET Only
Res | Basement or Crawlspace Insulation	Basement or Crawlspace Insulation R-12 or R-10	Minimal basement or crawlspace insulation, floor RSI-1.06	Space Cooling and Heating	Electric & Natural Gas	RET Only
Res | ENERGY STAR Dehumidifier	ENERGY STAR DEHUMIDIFIER - No Replacement/Replacement with New	Non-ENERGY STAR Dehumidifier	Space Cooling	Electric	RET Only
Res | Dehumidifier Recycling	Dehumidifier Recycling	No recycling	Space Cooling	Electric	RET Only

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Res | Heat Pump Clothes Dryer	Heat Pump Clothes Dryer	Standard Electric Clothes Dryer	Washing/Drying Appliances	Electric	ROB and NEW
Res | DHW Recirculation Systems	DHW Recirculation Systems (e.g., Metlund D'MAND®)	no DHW recirculation system	Water Heating	Electric & Natural Gas	RET Only
Res | Floor Insulation	Floor Insulation: R-30 or R-38	R-5 floor insulation	Space Cooling and Heating	Electric & Natural Gas	RET Only
Res | Pool Cover	Insulating Pool Covers	A pool with no insulating cover	Misc. Residential	Natural Gas	RET Only
Res | High Efficiency Gas Pool Heater	A high efficiency gas-fired pool heater (92.5% efficiency assumed)	A standard efficiency gas-fired pool heater (82.5% efficiency assumed)	Misc. Residential	Natural Gas	ROB Only
Res | ENERGY STAR Clothes Washer	ENERGY STAR Clothes Washers	Standard Clothes Washer	Washing/Drying Appliances	Electric & Natural Gas	ROB and NEW
Res | ENERGY STAR Windows	ENERGY STAR Windows (U=0.25/0.30/0.35, SHGC=0.40)	Standard windows	Space Cooling and Heating	Electric & Natural Gas	RET Only
Res | Furnace Tune-Up	Furnace Tune-Up	No maintenance/tune-up	Space Heating	Natural Gas	RET Only
Res | Furnace with ECM	ECM Retrofit for Electric Furnace	Standard electric furnace without ECM	Space Heating	Electric	RET Only
Res | Solar Powered Attic Fan	Solar Powered Attic Fan (per house)	Passive attic ventilation	Ventilation and Circulation	Electric	NEW Only
Res | Heat Pump Water Heater	Heat Pump Water Heaters (50 - 75 gallon) or (75+ gallon)	Standard Electric Storage Water Heater	Water Heating	Electric	ROB and NEW
Res | Solar Water Heating System	Active Solar Water Heating Systems	standard storage electric water heater	Water Heating	Electric & Natural Gas	ROB and NEW
Res | Solar Water Heating System	Active Solar Water Heating Systems	standard storage gas water heater	Water Heating	Electric & Natural Gas	ROB and NEW
Res | Passive Attic Ventilation	Attic Ventilation Passive Mechanical	No mechanical attic vent	Misc. Residential	Electric	RET Only
Res | Condensing Boiler	Condensing Gas Boiler (92% AFUE)	A non-condensing mid-efficiency Gas boiler (82% AFUE assumed)	Space Heating	Natural Gas	RET, ROB and NEW

Source: Navigant analysis

Table C-2. Residential Energy Efficiency Multifamily Measures

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Res | High Efficiency Condensing Furnace	High Efficiency Condensing Furnace AFUE 95% from 90% code	90% AFUE Furnace	Space Heating	Natural Gas	ROB and NEW
Res | Advanced BAS/Controllers	Advanced BAS/Controllers	No advanced BAS/Controllers	All	Electric & Natural Gas	RET Only

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Res | High Efficiency Chiller (avg of water and air cooled)	2018 IECC standard Water Cooled (Centrifugal Chiller-175 Tons to 600 tons, Reciprocating Chiller-50 to 300 Tons) and Air Cooled (100-150 Tons)	2012 IECC standard Water Cooled (Centrifugal Chiller-175 Tons to 600 tons, Reciprocating Chiller-50 to 300 Tons) and Air Cooled (100-150 Tons)	Space Cooling	Electric	ROB and NEW
Res | INTEGRAL LED TROFFERS	INTEGRAL LED TROFFERS, INTEGRAL LED TROFFERS RETROFIT KIT	Market baseline average (Three-lamp Std. T8 fixtures (4' 32 W) and Ubend 32 W- 2 lamp T8)	Lighting	Electric	RET Only
Res | LED High Bay Fixture	Interior High Bay LED	250 W Probe Start Metal Halide	Lighting	Electric	RET Only
Res | LED Recessed Downlights	LED Downlight with Light Output 800 lumens	ENERGY STAR 15 or 18 W CFL	Lighting	Electric	RET Only
Res | Occupancy Sensors MF	OCCUPANCY SENSORS - average of Ceiling mounted or switch plate mounted	No occupancy sensor	Lighting	Electric	RET Only
Res | Beverage Vending Machine Controls	BEVERAGE VENDING MACHINE CONTROLS or Vendor Miser	Standard beverage vending machines/No Vendor Miser	Refrigeration	Electric	RET, ROB and NEW
Res | Variable Frequency Drive (VFD)	VFD - Motor Size: <10 HP to >50 HP, 66% Load Factor	No VFD installed, Motor is at 75% Load Factor	Ventilation and Circulation	Electric	RET Only
Res | VFD on Pumps	VFD on Pumps	Motor without VFD Drive	Ventilation and Circulation	Electric	RET Only
Res | Central Lighting Control System	Central Lighting Control System	Lighting with No Controls	Lighting	Electric	ROB and NEW
Res | Building Recommissioning, Operations and Maintenance (O&M) Improvements	Building Recommissioning, O&M Improvements	No Building Recommissioning or O&M improvements	All	Electric & Natural Gas	RET Only
Res | CO Sensors for parking garage exhaust fans	CO sensors for parking garage exhaust fans	No CO sensors	Ventilation and Circulation	Electric	RET and NEW
Res | Condensing Make Up Air Unit	>=90% Thermal Efficiency Constant Speed MUAU	80% Thermal Efficiency, Conventional MUAU	Space Heating	Electric & Natural Gas	ROB and NEW
Res | HVAC Optimisation	Automated Control System, HVAC Diagnostic, Air Conditioner Tune-up	No optimisation	Space Cooling and Heating	Electric	ROB and NEW
Res | LED Tube Re-Lamp	LED TUBE RE-LAMP	Single-lamp 25 W T8	Lighting	Electric	ROB Only
Res | Demand Control Ventilation	Ventilation Optimisation (Includes demand control ventilation and energy recovery ventilation)	No ventilation optimisation	Ventilation and Circulation	Electric & Natural Gas	RET Only
Res | Duct Insulation MF	Duct insulation R-8	Duct insulation R-0	Space Cooling and Heating	Electric & Natural Gas	RET Only
Res | ECM MOTORS FOR HVAC APPLICATION (FAN-POWERED VAV BOX)	ECM MOTORS FOR HVAC APPLICATION (FAN-POWERED VAV BOX)	VAV Box with Permanent Split Capacitor (PSC) motors	Space Cooling	Electric	RET and NEW
Res | ENERGY STAR LED Lamps (General Service Lamps)	ENERGY STAR LED LAMPS - market average of (1. OMNIDIRECTIONAL A SHAPE OR WET LOCATION RATED PAR - 10 W& 2. LED Decorative Bulb)	Market baseline average(11-13 WCompact Fluorescent Lamp, 7 W CFL, 40 W Incandescent)	Lighting	Electric	RET, ROB and NEW

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Res | ENERGY STAR LED LAMPS (REFLECTOR LAMPs/MR16/PAR 16)	ENERGY STAR LED Lamps. Market average REFLECTOR (FLOOD/SPOT) LAMPs/MR16 GU5.3 BASE: 7W/PAR16 OR MR16 GU10 BASE: 7W	Market baseline average(11-13 W Compact Fluorescent Lamp, 7 W CFL, 40 W Incandescent)	Lighting	Electric	RET, ROB and NEW
Res | LED Exterior Area Lights - LED Fixture (200W)	LED EXTERIOR AREA LIGHTS - LED fixture (200W)	50 to 75 W MH/HPS	Lighting	Electric	RET, ROB and NEW
Res | Condensing Storage Water Heater	Non-condensing storage water heater, efficiency 80.1%	Condensing storage water heater, efficiency 94.5%	Water Heating	Natural Gas	ROB and NEW
Res | Chilled Water Optimisation	Optimisation of commercial chilled water equipment	No optimisation	Space Cooling	Electric	ROB and NEW
Res | LED Parking Lot Fixture	LED parking lot fixture	One 250 W HPS/MH parking fixture	Lighting	Electric	RET, ROB and NEW
Res | Photocell Controls (Outdoor)	Photocell Controls (Outdoor)	Lighting with No Controls	Lighting	Electric	RET Only
Res | Outside Air Economiser	Outside Air Economiser	No Economiser	Space Cooling	Electric	RET and NEW
Res | Condensing Boiler	90% AFUE	Standard boiler - 76% AFUE	Space Heating	Natural Gas	ROB and NEW
Res | Solar Water Preheat (Pools/DHW)	Solar Water Preheat (Pools/DHW)	Pool water heater, no solar preheat	Water Heating	Electric & Natural Gas	RET Only
Res | Solar Water Preheat (Pools/DHW)	Solar hot water preheat for pools	No preheat, standard pool hot water heater	Water Heating	Electric & Natural Gas	RET Only
Res | Variable Refrigerant Flow Heat Pump	Variable Refrigerant Flow Heat Pump	Std. Heat Pump	Space Cooling and Heating	Electric	RET, ROB and NEW
Res | Wall Insulation MF	Wall Insulations (Going from R23 to R30/R38 mkt average)	No wall insulation	Space Cooling and Heating	Electric & Natural Gas	RET Only

Source: Navigant analysis

Table C-3. Residential Fuel Switching Measure List

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Res | Electric Air Source Cold Climate Heat Pump	Electric Air Source Cold Climate Heat Pumps (3 ton capacity)	High Efficiency Furnace, AFUE 90	Space Heating	Electric & Natural Gas	ROB and NEW
Res | Ground Source Heat Pump	Electric Ground Source Heat Pumps	High Efficiency Furnace, AFUE 90	Space Heating	Electric & Natural Gas	ROB and NEW
Res | Solar Pool Heaters	Solar Panels for pool heating. Old gas pool heaters must be removed to qualify.	Gas Pool Heater	Water Heating	Electric & Natural Gas	ROB and NEW

Source: Navigant analysis

Table C-4. Commercial Energy Efficiency Measure List

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Com | Adding reflective (White) roof treatment or a green roof	Cool roof	Conventional roof	Space Cooling and Heating	Electric	RET and NEW

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Com | Demand Control Kitchen Ventilation	New commercial kitchen exhaust hoods with rate capacity of not more than 15,000 CFM, equipped with DCV systems	A new constant volume kitchen exhaust hood with rated capacity not greater than 15,000 CFM	Ventilation and Circulation	Electric & Natural Gas	RET, ROB and NEW
Com | VFD	VFD - Motor Size: <10 HP to >50 HP, 66% Load Factor	No VFD installed, Motor is at 75% Load Factor	Ventilation and Circulation	Electric	RET Only
Com | VFD on Pumps	VFD on Pumps	Motor without VFD Drive	Misc. Commercial	Electric	RET Only
Com | Anti-sweat heat (ASH) controls - Cooler/Freezer	ASH controls - Cooler/Freezer	No controls installed, System without ASH Controls	Refrigeration	Electric	RET and NEW
Com | Advanced BAS/Controllers	Advanced BAS/Controllers	No advanced BAS/Controllers	All	Electric & Natural Gas	RET and NEW
Com | Demand Control Ventilation	Demand Control Ventilation	New single-zone, constant volume ventilation system	Ventilation and Circulation	Electric & Natural Gas	RET, ROB and NEW
Com | Auto-Off Time Switch or Time Clock control	Auto-Off Time Switch or Time Clock control	Lighting with No Controls	Lighting	Electric	RET and NEW
Com | Auto-Off Time Switch or Time Clock control	Auto-Off Time Switch or Time Clock control	ENERGY STAR 15 or 18 WCFL	Lighting	Electric	RET and NEW
Com | Ozone Laundry Treatment	Ozone Laundry Treatment	Commercial laundry with no ozone treatment system	Water Heating	Electric & Natural Gas	RET and NEW
Com | BEVERAGE VENDING MACHINE CONTROLS	BEVERAGE VENDING MACHINE CONTROLS or Vendor Miser	Standard beverage vending machines/No Vendor Miser	Refrigeration	Electric	RET, ROB and NEW
Com | Boilers - Advanced Controls (Steam Systems)	Boilers - Advanced Controls (Steam Systems)	Boilers with linkage controls	Space Heating	Natural Gas	RET and NEW
Com | Building Recommissioning, O&M Improvements	Building Recommissioning, O&M Improvements	No Building Recommissioning or O&M improvements	All	Electric & Natural Gas	RET Only
Com | HOTEL OCCUPANCY CONTROLS (HVAC + LIGHTING)	HOTEL OCCUPANCY CONTROLS (HVAC + LIGHTING)	No controls installed	Space Cooling and Heating	Electric & Natural Gas	RET and NEW
Com | CEE Tier 2/ENERGY STAR Clothes Washers	CEE Tier 2/ENERGY STAR Clothes Washers	Conventional top loading vertical axis washers (MEF = 1.26, WF=9.5, tub size = 2.8 ft3)	Misc. Commercial	Electric & Natural Gas	ROB and NEW
Com | Roof Insulation/Ceiling Insulation (R25 Code to R35)	Roof Insulation/Ceiling Insulations (R25 Code to R35)	R-10 roof/R-25 ceiling insulation	Space Heating	Electric & Natural Gas	RET and NEW
Com | Centrally controlled desktop PC/NETWORK PC POWER MANAGEMENT SOFTWARE	Centrally controlled desktop PC/NETWORK PC POWER MANAGEMENT SOFTWARE	No software installed	Computer Equipment	Electric	RET, ROB and NEW
Com | CO Sensors for parking garage exhaust fans	CO sensors for parking garage exhaust fans	No CO sensors	Ventilation and Circulation	Electric	RET and NEW
Com | Condensing Make Up Air Unit	>=90% Thermal Efficiency Constant Speed MUAU	80% Thermal Efficiency, Conventional MUAU	Space Heating	Electric & Natural Gas	ROB and NEW
Com | Condensing Unit Heaters or other Efficient Unit Heating System	Condensing Unit Heaters or other Efficient Unit Heating System	Standard Unit Heaters	Space Heating	Electric & Natural Gas	RET, ROB and NEW

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Com | Condensing Unit Heaters or other Efficient Unit Heating System	Condensing Unit Heaters or other Efficient Unit Heating System	70%-80% Efficiency	Space Heating	Electric & Natural Gas	RET, ROB and NEW
Com | Duct Insulation, R8	Duct Insulation, add R8	No duct insulation	Space Cooling and Heating	Electric & Natural Gas	RET Only
Com | EC Plug Fan for Data Centre (under cabinet)	Electrically Commutated Plug Fans in data centres under Cabinet	Standard Fan	Other Plug Load	Electric	RET and NEW
Com | Central Lighting Control System	Central Lighting Control System	Lighting with No Controls	Lighting	Electric	ROB and NEW
Com | ECM MOTORS FOR HVAC APPLICATION (FAN-POWERED VAV BOX)	ECM MOTORS FOR HVAC APPLICATION (FAN-POWERED VAV BOX)	VAV Box with PSC motors	Space Cooling	Electric	RET and NEW
Com | Education and Capacity Building/Energy Behaviour	Education and Capacity Building/Energy Behaviour	Nothing	All	Electric & Natural Gas	RET Only
Com | Elec Storage WH 2.30 Et	High Efficiency Storage Water Heater	Standard tank water heater (50 gal)	Water Heating	Electric	RET, ROB and NEW
Com | Energy Efficient Laboratory Fume Hood	Energy Efficient Laboratory Fume Hood	Fume Hood without VFD Drive	Space Heating	Electric & Natural Gas	RET Only
Com | ENERGY STAR FREEZER	ENERGY STAR FREEZER - (avg of solid door & glass door)	Standard Freezer	Refrigeration	Electric	RET, ROB and NEW
Com | ENERGY STAR Fryer (84% eff)	ENERGY STAR Fryer Replacing Standard Fryer	Non-ENERGY STAR rated Fryers	Cooking	Electric & Natural Gas	ROB and NEW
Com | Exterior Photocell	Add Photocell to Exterior Lighting System	Lighting with No Controls	Lighting	Electric	RET Only
Com | ENERGY STAR Griddle (74% eff)	ENERGY STAR Griddle Replacing Standard Griddle	Non-ENERGY STAR rated Griddle	Cooking	Electric & Natural Gas	ROB and NEW
Com | ENERGY STAR LED LAMPS (General Service Lamps)	ENERGY STAR LED LAMPS - market average of (1. OMNIDIRECTIONAL A SHAPE OR WET LOCATION RATED PAR - 10 W& 2. LED Decorative Bulb)	Market baseline average (11-13 WCompact Fluorescent Lamp, 7 W CFL, 40 W Incandescent)	Lighting	Electric	RET, ROB and NEW
Com | Demand controlled Circulating Systems	Demand controlled Circulating Systems	No Demand Control	Water Heating	Natural Gas	RET Only
Com | ENERGY STAR LED LAMPS (REFLECTOR LAMPs/MR16/PAR 16)	ENERGY STAR LED Lamps. Market average REFLECTOR (FLOOD/SPOT) LAMPs/MR16 GU5.3 BASE: 7W/PAR16 OR MR16 GU10 BASE: 7W	Market baseline average (11-13 WCompact Fluorescent Lamp, 7 W CFL, 40 W Incandescent)	Lighting	Electric	RET, ROB and NEW
Com | ENERGY STAR Refrigerator	ENERGY STAR REFRIGERATOR - (avg of solid door & glass door)	Standard Refrigerator	Refrigeration	Electric	RET, ROB and NEW
Com | Commercial Hot Food Holding Cabinets	Commercial Hot Food Holding Cabinets (ENERGY STAR)	Standard Cabinet	Cooking	Electric	ROB and NEW
Com | ENERGY STAR Dishwasher	ENERGY STAR Dishwasher	Non-ENERGY STAR rated Dishwasher (Stationary Single Tank Door)	Cooking	Electric & Natural Gas	RET, ROB and NEW
Com | ENERGY STAR Dishwasher	ENERGY STAR Dishwasher	Non-ENERGY STAR rated Dishwasher (Stationary Single Tank Door)	Water Heating	Electric & Natural Gas	RET, ROB and NEW
Com | Furnace Tune-Up	Furnace Tune-Up	No furnace tune-up	Space Heating	Electric & Natural Gas	RET Only
Com | Heat Recovery Ventilator	Average of equipment that incorporates energy recovery	No Energy Recovery Ventilator	Ventilation and Circulation	Natural Gas	RET, ROB and NEW

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Com | High Efficiency Induction Cooking	High Efficiency Induction Cooking	Standard Cooking	Cooking	Electric	RET, ROB and NEW
Com | High Efficiency Small Instantaneous Water Heater	High Efficiency Small Instantaneous Water Heater	Std. tank Water heater (50 Gallon)	Water Heating	Electric	RET, ROB and NEW
Com | Indoor Daylight Sensors/Photocell Dimming Control	Indoor Daylight Sensors/Photocell Dimming Control	Lighting with No Controls	Lighting	Electric	RET and NEW
Com | Indoor Daylight Sensors/Photocell Dimming Control	LED Downlight with Light Output 800 lumens	ENERGY STAR 15 or 18 W CFL	Lighting	Electric	RET and NEW
Com | Efficient compressor motor	Efficient compressor motor	Baseline Refrigeration System - Grocery	Refrigeration	Electric	RET Only
Com | ECM MOTORS FOR EVAPORATOR FANS for refrigeration (WALK-IN)	ECM MOTORS FOR EVAPORATOR FANS for refrigeration (WALK-IN)	Shaded Pole Motor and/or PSC	Refrigeration	Electric	RET Only
Com | LED EXTERIOR AREA LIGHTS - LED fixture (200W)	LED EXTERIOR AREA LIGHTS - LED fixture (200W)	50 to 75 WMH/HPS	Lighting	Electric	RET, ROB and NEW
Com | LED or Equivalent Sign Lighting	LED or Equivalent Sign Lighting	Fluorescent (T12 High Output) or Neon Electric Signage	Lighting	Electric	RET, ROB and NEW
Com | Air Curtains	Air Curtains	Non-air curtain doors or New construction	Space Cooling and Heating	Electric & Natural Gas	RET and NEW
Com | Networked/Connected - High Impact Application	Networked/Connected - High Impact Application	Standard 32 W T8 & 28 W T8	Lighting	Electric	RET Only
Com | Networked/Connected - Low Impact Application	Networked/Connected - Low Impact Application	T8HO and T5HO Systems	Lighting	Electric	RET Only
Com | Freezer Case Light Sensor	Freezer Case Light Sensor	No sensor	Lighting	Electric	RET Only
Com | LLLC - High Impact Application	LLLC - High Impact Application	Standard 32 W T8 & 28 W T8	Lighting	Electric	RET Only
Com | LLLC - Low Impact Application	LLLC - Low Impact Application	T8HO and T5HO Systems	Lighting	Electric	RET Only
Com | Air Handler with Dedicated Outdoor Air Systems	Air Handler with Dedicated Outdoor Air Systems	Air Handler without Dedicated Outdoor Air Systems	Ventilation and Circulation	Natural Gas	RET Only
Com | Refrigerated Display Case Doors	New display case with doors (Low temperature)	Open low temperature display case	Refrigeration	Electric	ROB and NEW
Com | LED parking lot fixture	LED parking lot fixture	One 250 W HPS/MH parking fixture	Lighting	Electric	RET, ROB and NEW
Com | Temperature Adjustment in Commercial Freezers	Temperature Adjustment in Commercial Freezers (temperature setpoint raised to -15C, an increase of 3 degrees Celsius)	No temperature adjustment (temperature setpoint of -18C)	Refrigeration	Electric	RET Only
Com | Gas Heat Pump Water Heater	Gas heat pump water heating (GAHP - gas absorption heat pump)	NG baseline case	Water Heating	Natural Gas	ROB and NEW
Com | Ice Rink Heat Recovery	Ice rink heat recovery (mostly gas savings unless electrically heated)	Ice rink with no heat recovery	Misc. Commercial	Natural Gas	RET Only
Com | Steam System Optimisation	Steam System Optimisation	Current steam system with no optimisation	Space Heating	Natural Gas	RET Only
Com | LED Replacement Lamp (Tube)	LED Replacement Lamp (Tube)	Standard 32 W T8 & 28 W T8	Lighting	Electric	ROB and NEW
Com | LED Troffer/Surface/Suspended	LED Troffer/Surface/Suspended	Standard 32 W T8 & 28 W T8	Lighting	Electric	RET Only

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Com | LED Low/High Bay	LED Low/High Bay	T8HO and T5HO Systems	Lighting	Electric	RET Only
Com | LED RECESSED DOWNLIGHTS	LED Downlight with Light Output 800 lumens	ENERGY STAR 15 or 18 W CFL	Lighting	Electric	RET, ROB and NEW
Com | ENERGY STAR Steam Cookers	ENERGY STAR Steam Cooker Replacing Standard Steam Cooker	Boiler-Based Steam Cooker or Steamer that does not meet minimum ENERGY STAR requirements (6 pans)	Cooking	Electric	ROB and NEW
Com | High Efficiency Condensing Furnace AFUE 95% from 80% code	95% from 80% code	80% AFUE Furnace	Space Heating	Natural Gas	RET Only
Com | Ground Source Heat Pump	Ground Source Heat Pump replacing Air Source Heat Pump	Air Source Heat Pump of similar size	Space Cooling and Heating	Electric	ROB and NEW
Com | LED street light fixture	LED street light fixture	One 250 W HPS/MH street light	Lighting	Electric	RET, ROB and NEW
Com | ENERGY STAR Steam Cooker	ENERGY STAR Steam Cooker Replacing Standard Steam Cooker	Non-ENERGY STAR rated Steam Cookers	Cooking	Natural Gas	ROB and NEW
Com | High Efficiency Chiller (avg of water and air cooled)	Higher than 2018 IECC code baseline	2018 IECC standard Water Cooled (Centrifugal Chiller-175 Tons to 600 tons, Reciprocating Chiller-50 to 300 Tons) and Air Cooled (100-150 Tons)	Space Cooling	Electric	ROB and NEW
Com | HVAC Optimisation	Automated Control System, HVAC Diagnostic, Air Conditioner Tune-up	No optimisation	Space Cooling	Electric	ROB and NEW
Com | High Efficiency Air Source Heat Pump	High efficiency replacing low efficiency ASHP	ASHP of similar size	Space Cooling and Heating	Electric	ROB and NEW
Com | Energy Recovery Ventilation and Ventilation (Enhanced)	Average of equipment that incorporates energy recovery	No Energy Recovery Ventilator	Ventilation and Circulation	Electric & Natural Gas	RET, ROB and NEW
Com | Low Flow Pre-Rinse Spray Nozzle	Low Flow Pre-Rinse Spray Nozzle	Standard valve	Water Heating	Electric & Natural Gas	ROB Only
Com | Notched V belts for HVAC Systems	Notched V belts for HVAC Systems	V-Belt with Motor Size: 1 HP, 75% Load Factor	Space Heating	Electric	RET, ROB and NEW
Com | High Efficiency Underfired Broilers	High efficiency replacing conventional measure	Conventional underfired broiler	Cooking	Natural Gas	ROB and NEW
Com | Occupancy Sensors	OCCUPANCY SENSORS - average of Ceiling mounted or switch plate mounted	No occupancy sensor	Lighting	Electric	RET and NEW
Com | Occupancy Sensors	LED Downlight with Light Output 800 lumens	ENERGY STAR 15 or 18 W CFL	Lighting	Electric	RET and NEW
Com | Outside Air Economiser	Outside Air Economiser	No Economiser	Space Cooling	Electric	RET and NEW
Com | Infrared Heaters	Infrared Heater replacing conventional unit heater	Conventional Unit Heater	Space Heating	Natural Gas	ROB and NEW
Com | VSD Air Compressor	VSD Air Compressor	No VSD on Air Compressor	Misc. Commercial	Electric	ROB and NEW
Com | Smart Strip Plug Outlets	Smart Strip Plug Outlet	Standard plug outlet	Other Plug Load	Electric	ROB and NEW
Com | Reach-in Shaded Pole to ECM/PSC Evaporator Fan Motor	Reach-in Shaded Pole to ECM/PSC Evaporator Fan Motor	Shaded Pole Evaporator Fan Motor	Refrigeration	Electric	ROB and NEW
Com | Condensing Boiler | Std	90% AFUE	Standard boiler - 76% AFUE	Space Heating	Natural Gas	ROB and NEW

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Com | Destratification	Destratification Fan	No Destratification	Space Heating	Natural Gas	RET Only
Com | Super High Perf Glazing |New	Super High Performance Glazing	Standard double glazing with overall U-value of 0.46 Btu/hr.ft	Space Heating	Natural Gas	NEW Only
Com | Super High Perf Glazing |RET	Super High Performance Glazing	Standard double glazing with overall U-value of 0.46 Btu/hr.ft	Space Heating	Natural Gas	RET Only
Com | Drain Water Heat Recovery (DWHR) |New	DWHR	No heat recovery	Water Heating	Natural Gas	NEW Only
Com | DWHR | Retro	DWHR	No heat recovery	Water Heating	Natural Gas	RET Only
Com | PTAC (12 EER/10,000 Btu)	High efficiency PTAC	Existing PTAC	Space Cooling and Heating	Electric	ROB Only
Com | Water Source Heat Pump (4 ton)	Heat pump, geothermal or water source	Existing HP equipment below ASHRAE 2010 standards	Space Cooling and Heating	Electric	ROB and NEW
Com | Adaptive Thermostats	Smart Thermostat	Standard Thermostat	Space Cooling and Heating	Electric & Natural Gas	RET and NEW
Com | Unitary Air Conditioning Unit	High efficiency units	Existing AC/HP equipment below ASHRAE 2010 standards	Space Cooling	Electric	ROB and NEW
Com | Solar Electric Water Heater (50 Gallon)	Solar Hot Water Heater	Electric Storage Water Heater with 0.90 EF	Water Heating	Electric	ROB and NEW
Com | Refrigerated Display Case LED	REFRIGERATED DISPLAY CASE LED FIXTURE - HORIZONTAL (UNDERSHELF) INSTALLATION or Vertical Installation	Average of 2'-4' T8 (17 W, 25 W, 32 W)	Lighting	Electric	RET, ROB and NEW
Com | Refrigerated Display Case LED	LED Downlight with Light Output 800 lumens	ENERGY STAR 15 or 18 W CFL	Lighting	Electric	RET, ROB and NEW
Com | Room AC (w/ louvered sides) 14 SEER from 12 SEER code	ENERGY STAR Qualifying Room AC 12.5 SEER, ENERGY STAR Qualifying Room AC 13 SEER, ENERGY STAR Qualifying Room AC 14 SEER	12 SEER Room AC	Space Cooling	Electric	ROB and NEW
Com | Water Heating (DHW) Pipe Insulation (Add 3/4" Foam)	Water Heating (DHW) Pipe Insulation (Add 3/4" Foam)	N/A - Retrofit Only	Water Heating	Electric	RET Only
Com | High R-Value Glass Doors/no heat glass door	High R-Value Glass Doors/no heat glass door	Standard Refrigeration	Refrigeration	Electric	RET Only
Com | Refrigeration Optimisation	Refrigeration Optimisation	No optimisation	Refrigeration	Electric	ROB and NEW
Com | Chilled Water Optimisation	Chilled water optimisation	No optimisation	Space Cooling	Electric	ROB and NEW
COM | Ductless Mini-Split Heat Pumps	Ductless heat pump	Code Level Ductless Mini-Split Heat Pumps	Space Cooling and Heating	Electric	ROB and NEW
Com | Heat Pump Water Heater (50 Gallons)	Heat Pump Water Heater (50 Gallon)	Std. tank Electric Water heater (50 Gallon)	Water Heating	Electric	ROB and NEW
Com | Thermostat Setback	Water Heater Thermostat Setback	Standard thermostat, no setback	Water Heating	Electric	ROB and NEW
Com | Solar Preheat Make up Air	Solar air preheat panel	1,500 CFM of supply air is heated by a natural gas source at 80% thermal efficiency (78% seasonal)	Space Heating	Electric & Natural Gas	RET Only

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Com | Solar Preheat Make up Air	Solar air preheat panel	No preheated air ventilation	Space Heating	Electric & Natural Gas	RET Only
Com | Solar Water Preheat (Pools/DHW)	Solar Water Preheat (Pools/DHW)	Pool water heater, no solar preheat	Water Heating	Electric & Natural Gas	ROB and NEW
Com | Strip Curtains	Strip Curtains	Walk-in Unit Door with no Strip Curtain	Refrigeration	Electric	RET and NEW
Com | Condensing Tankless Water Heater	Condensing Tankless Water Heaters	Standard non-condensing storage water heater	Water Heating	Natural Gas	ROB and NEW
Com | Condensing Storage Water Heater	Condensing Storage Water Heaters	Standard non-condensing storage water heater	Water Heating	Natural Gas	ROB and NEW
Com | Gas-Fired Rooftop Units	Gas-Fired Rooftop Units (two-stage)	One Stage gas-fired rooftop unit	Space Heating	Natural Gas	ROB and NEW
Com | Gas-Fired Heat Pump	Gas-Fired Heat Pumps	Standard Heat Pump	Space Heating	Natural Gas	ROB and NEW
Com | ENERGY STAR ICE MACHINES - Ice Making Head	ENERGY STAR ICE MACHINES - Ice Making Head	Standard, inefficient ice machine	Refrigeration	Electric	ROB Only
Com | Evaporator Coil Defrost (Cooler)	Evaporator Coil Defrost Control (Cooler)	no electric defrost on evaporator coil	Refrigeration	Electric	RET Only
Com | Evaporator Fan Controls	Evaporator Fan Control	No fan controls	Refrigeration	Electric	RET Only
Com | Electric Convection Combination Ovens	Convection Oven ENERGY STAR (74% Eff) & Electric combination oven ENERGY STAR	Standard Convection Combination Oven	Cooking	Electric	ROB and NEW
Com | Gas Convection Oven	Convection Oven ENERGY STAR (74% Eff) & Electric combination oven ENERGY STAR	Standard Convection Combination Oven	Cooking	Natural Gas	ROB and NEW
Com | Vertical Night Covers	Vertical Night Covers	No Night Covers	Refrigeration	Electric	RET Only
Com | Refrigeration Waste Heat Recover	Refrigeration Waste Heat Recovery	No heat recovery	Refrigeration	Natural Gas	ROB and NEW
Com | Super High Efficiency Furnaces (Emerging Tech)	95% from 90%	90% AFUE Furnace	Space Heating	Electric & Natural Gas	ROB and NEW
Com | Super High Efficiency Furnaces (Emerging Tech)	95% from 90% code	Condensing Furnace, AFUE 90%	Space Heating	Electric & Natural Gas	ROB and NEW
Com | Data Centre Storage/Server Virtualisation	Data Centre - Server/Storage Virtualisation	Existing servers in office (No Server Virtualisation)	Other Plug Load	Electric	ROB Only
Com | eCube	eCube	Standard refrigeration, no eCube	Refrigeration	Electric	NEW Only
Com | Door Gasket Freezer/Refrigerator	Door Gasket- Freezer/Refrigerator	No Gasket	Refrigeration	Electric	ROB Only
Com | Suction Pipe Insulation Freezer/Refrigerator	Suction Pipe Insulation - Refrigerator/Freezer	uninsulated suction pipe	Refrigeration	Electric	RET Only
Com | Heat Reflector Panel	Heat Reflector Panels	Standard radiators	Space Heating	Electric	RET Only
Com | SYNCHRONOUS BELT	SYNCHRONOUS BELT - Motor Size: <10 HP to >50 HP, 73.5% Load Factor	V-Belt with Motor Size: 1 HP, 75% Load Factor	Space Heating	Electric	RET, ROB and NEW
Com | Dock Door Seals	Dock Door Seals	No door seals	Misc. Commercial	Natural Gas	ROB and NEW
Com | Refrigeration Commissioning	Refrigeration Commissioning	Standard Refrigeration	Refrigeration	Electric	RET Only

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Com | Boiler Measures	High Efficiency Boilers (High Efficiency Burners, Feedwater Economisers, Combustion Air Preheat, Blowdown Heat Recovery)	Standard Boiler	Space Heating	Natural Gas	ROB and NEW
Com | Variable Refrigerant Flow Heat Pump	Variable Refrigerant Flow Heat Pump	Std. Heat Pump	Space Heating	Electric	RET, ROB and NEW
Com | Wall Insulation	Wall Insulations (Going from R23 to R30/R38 mkt average)	Wall Insulation, R23	Space Cooling and Heating	Electric & Natural Gas	RET Only

Source: Navigant analysis

Table C-5. Commercial Fuel Switching Measure List

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Com | Air Source Heat Pump (Air to Air)	Air Source Heat Pump (Air to Air) with COP 2.5	GB: Code-compliant non-condensing gas boiler with AFUE of 80%	Space Heating	Electric & Natural Gas	ROB and NEW
Com | Air to Water Heat Pump COP 2.7	Air to Water Heat Pump COP 2.7	Code-compliant non-condensing gas boiler with AFUE of 80%	Space Heating	Electric & Natural Gas	ROB and NEW
Com | Heat Pump Water Heater (Air to Water)	Heat pump water heater (air to water) with 2.0 COP	Code-compliant gas storage water heater with 80% thermal efficiency	Water Heating	Electric & Natural Gas	ROB and NEW
Com | Electric Air Source Cold Climate Heat Pump (Fuel Switching)	Electric Air Source Cold Climate Heat Pumps	Gas space heating/<65,000 Btu	Space Heating	Electric & Natural Gas	ROB and NEW
Com | Ground Source Heat Pump (Fuel Switching)	Ground Source Heat Pump (market average of Closed loop & Open loop)	Gas space heating/<65,000 Btu	Space Heating	Electric & Natural Gas	ROB and NEW

Source: Navigant analysis

Table C-6. Industrial Energy Efficiency Measure List

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Ind | Air Compressor Heat Recovery	Air Compressor Heat Recovery	No Heat Recovery	HVAC	Electric & Natural Gas	RET Only
Ind | Air Compressor Heat Recovery	Air Compressor Heat Recovery	No Heat Recovery	Process Heating (Direct)	Electric & Natural Gas	RET Only
Ind | Air Leak Survey and Repair	Air Leak Survey and Repair	No Survey Conducted	Compressed Air	Electric	RET Only
Ind | Air Compressor Optimisation	HE Compressor motors, Variable Displacement Air Compressor, Improved Controls - Air Compressor, Receiver Capacity Addition, VFD Controlled Compressor, Variable Displacement Air Compressor, Optimise Excess Air	As is Compressor	Compressed Air	Electric	RET, ROB and NEW

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Ind | Air Compressor Optimisation	HE Compressor motors, Variable Displacement Air Compressor, Improved Controls - Air Compressor, Receiver Capacity Addition, VFD Controlled Compressor, Variable Displacement Air Compressor, Optimise Excess Air	As is Compressor	Compressed Air	Electric	RET, ROB and NEW
Ind | Boiler Upgrade	Boiler Upgrade	Current/Standard Boiler System	Process Heating (Water and Steam)	Natural Gas	RET, ROB and NEW
Ind | Boiler Upgrade	Boiler Upgrade	Current/Standard Boiler System	Process Heating (Water and Steam)	Natural Gas	RET, ROB and NEW
Ind | Clean Room Upgrades	Clean Room Upgrades	Standard Clean Room	Process Cooling	Electric	RET, ROB and NEW
Ind | Clean Room Upgrades	Clean Room Upgrades	Standard Clean Room	Process Cooling	Electric	RET, ROB and NEW
Ind | Dairy Pre-Cooler	Dairy Pre-Cooler	Standard Process Cooling	Process Cooling	Electric	RET, ROB and NEW
Ind | Dairy Pre-Cooler	Dairy Pre-Cooler	Standard Process Cooling	Process Cooling	Electric	RET, ROB and NEW
Ind | Dairy Water Heater	Dairy Water Heater	Standard electric hot water heater	Process Heating (Water and Steam)	Electric	RET, ROB and NEW
Ind | Dairy Water Heater	Dairy Water Heater	Standard electric hot water heater	Process Heating (Water and Steam)	Electric	RET, ROB and NEW
Ind | Direct Contact Water Heaters	Direct Contact Water Heaters	Indirect water heater	Process Heating (Water and Steam)	Natural Gas	RET, ROB and NEW
Ind | Chiller Optimisation	Chiller Optimisation	No tune-up	Process Cooling	Electric	RET Only
Ind | Cooling Tower Optimisation	Cooling Tower Optimisation	Standard Practice Cooling Tower	Process Cooling	Electric	RET Only
Ind | Process Optimisation (Elec)	Process Optimisation	Standard Process (varies by segment)	All	Electric	RET Only
Ind | Direct Contact Water Heaters	Direct Contact Water Heaters	Indirect water heater	Process Heating (Water and Steam)	Natural Gas	RET, ROB and NEW
Ind | Dual and Natural Exhaust Ventilation Systems	Dual and Natural Exhaust Ventilation Systems	Standard Ventilation System	Motors - Fans/Blowers	Electric	RET, ROB and NEW
Ind | HE HVAC Units	High Efficiency HVAC Units	Standard Efficiency HVAC Units	HVAC	Electric & Natural Gas	RET, ROB and NEW
Ind | HE HVAC Units	High Efficiency HVAC Units	Standard Efficiency HVAC Units	HVAC	Electric & Natural Gas	RET, ROB and NEW
Ind | Dual and Natural Exhaust Ventilation Systems	Dual and Natural Exhaust Ventilation Systems	Standard Ventilation System	Motors - Fans/Blowers	Electric	RET, ROB and NEW
Ind | Improved Controls - Process Cooling	Process Cooling Controls	No Controls Installed	Process Cooling	Electric	RET Only

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Ind | Efficient Compressed Air Nozzles	Efficient Compressed Air Nozzles	Compressed air blow-off application without engineered nozzle	Compressed Air	Electric	RET, ROB and NEW
Ind | Efficient Compressed Air Nozzles	Efficient Compressed Air Nozzles	Compressed air blow-off application without engineered nozzle	Compressed Air	Electric	RET, ROB and NEW
Ind | Improved Controls - Process Heating	Improved Controls - Process Heating	No Controls installed	Process Heating (Direct)	Electric	RET Only
Ind | Process Heat Recovery	Process Heat Recovery	No Heat Recovery	Process Heating (Direct)	Electric	RET Only
Ind | VAV Conversion Project	VAV Conversion Project	Constant Volume System	HVAC	Electric	RET Only
Ind | Cold Storage Retrofit	Cold Storage Retrofit	No Retrofit	Process Cooling	Electric	RET Only
Ind | Free Cooling	Free Cooling and New A/C Units	Standard Process Cooling	Process Cooling	Electric	RET Only
Ind | Efficient Irrigation	Drip Irrigation, SIS	Standard Irrigation System	Motors - Pumps	Electric	RET, ROB and NEW
Ind | Efficient Irrigation	Drip Irrigation, SIS	Standard Irrigation System	Motors - Pumps	Electric	RET, ROB and NEW
Ind | Optimise Compressed Air Dryer	Optimise Compressed Air Dryer	Existing Air Dryer	Compressed Air	Electric	RET Only
Ind | Efficient Refrigeration Compressor	Efficient Refrigeration Compressor (Dairy)	Old Reciprocating compressor	Other Process	Electric	RET, ROB and NEW
Ind | Efficient Refrigeration Compressor	Efficient Refrigeration Compressor (Dairy)	Standard Refrigeration Compressor	Other Process	Electric	RET, ROB and NEW
Ind | Efficient Transformer	Efficient Transformer	Minimum Efficiency Transformer	Other Process	Electric	RET, ROB and NEW
Ind | Efficient Transformer	Efficient Transformer	Minimum Efficiency Transformer	Other Process	Electric	RET, ROB and NEW
Ind | Fan System Optimisation	Fan System Optimisation	No Fan System Optimisation	Motors - Fans/Blowers	Electric	RET, ROB and NEW
Ind | Fan System Optimisation	Fan System Optimisation	No Fan System Optimisation	Motors - Fans/Blowers	Electric	RET, ROB and NEW
Ind | Greenhouse Envelope Improvements	Greenhouse Envelope Improvements	In Situ Greenhouse	HVAC	Natural Gas	RET, ROB and NEW
Ind | Synchronous Belts	Synchronous Belts	V-Belt	Motors - Fans/Blowers	Electric	RET Only
Ind | Greenhouse Envelope Improvements	Greenhouse Envelope Improvements	Standard Greenhouse	HVAC	Natural Gas	RET, ROB and NEW
Ind | Greenhouse Grow Lights	LED Grow Lights	Standard (HPS or Fluorescent) Grow Lights	Lighting	Electric	RET, ROB and NEW
Ind | Process Improvements	Process Improvements - General	Standard Process	Other Process	Electric	RET Only
Ind | Pulp and Paper Process Improvements	Pulp and Paper Process Improvements	No Improvements	Motors - Pumps	Electric	RET Only
Ind | Greenhouse Grow Lights	LED Grow Lights	Standard (HPS or Fluorescent) Grow Lights	Lighting	Electric	RET, ROB and NEW
Ind | HE HVAC Controls	HVAC Control Systems	Standard HVAC Controls	HVAC	Electric & Natural Gas	RET Only

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Ind | HE HVAC Controls	HVAC Control Systems	Standard HVAC Controls	HVAC	Electric & Natural Gas	RET Only
Ind | HE Lighting	High Efficiency Lighting (LED)	Standard Efficiency Lighting	Lighting	Electric	RET, ROB and NEW
Ind | HE Lighting	High Efficiency Lighting (LED)	Standard Efficiency Lighting	Lighting	Electric	RET, ROB and NEW
Ind | HE Stock Tank	High Efficiency Stock Tank	Standard Stock Tank	Process Heating (Water and Steam)	Natural Gas	RET, ROB and NEW
Ind | SEM	Strategic Energy Management	No SEM	All	Electric	RET Only
Ind | HE Stock Tank	High Efficiency Stock Tank	Standard Stock Tank	Process Heating (Water and Steam)	Natural Gas	RET, ROB and NEW
Ind | Heat Lamps/Heat Pad	Efficient Heat Lamps/Creep Heat Pads	Standard Heating	Process Heating (Direct)	Electric	RET, ROB and NEW
Ind | Heat Lamps/Heat Pad	Efficient Heat Lamps/Creep Heat Pads	Standard Heating	Process Heating (Direct)	Electric	RET, ROB and NEW
Ind | High Efficiency Battery Charger	Three-phase High Frequency Battery Charger - 1-3 shifts	Ferroresonant or SCR battery chargers	Other Process	Electric	RET, ROB and NEW
Ind | High Efficiency Battery Charger	Three-phase High Frequency Battery Charger - 1-3 shifts	Ferroresonant or SCR battery chargers	Other Process	Electric	RET, ROB and NEW
Ind | High Efficiency Burners	High Efficiency Burners	In Situ Burners	Process Heating (Direct)	Natural Gas	RET, ROB and NEW
Ind | High Efficiency Burners	High Efficiency Burners	Industry Standard	Process Heating (Direct)	Natural Gas	RET, ROB and NEW
Ind | High Efficiency Furnaces	High Efficiency Furnaces	Standard Efficiency Furnaces	Process Heating (Direct)	Natural Gas	RET, ROB and NEW
Ind | Creep Heat Controller	Creep Heat Controller	Poorly Controlled Creep Heat Lamps	Other Process	Electric	RET Only
Ind | High Efficiency Furnaces	High Efficiency Furnaces	Standard Efficiency Furnaces	Process Heating (Direct)	Natural Gas	RET, ROB and NEW
Ind | High Efficiency HVAC Fans	High Efficiency HVAC Fans	Standard Fan HVAC System	HVAC	Electric	RET, ROB and NEW
Ind | High Efficiency HVAC Fans	High Efficiency HVAC Fans	Standard Fan HVAC System	HVAC	Electric	RET, ROB and NEW
Ind | High Efficiency HVAC Fans (Gas)	High Efficiency HVAC Fans	Standard Fan HVAC System	HVAC	Natural Gas	RET, ROB and NEW
Ind | Engine Block Heater Timer	ENGINE BLOCK HEATER TIMER	Manual plug-in block heater	Other Process	Electric	RET Only
Ind | High Efficiency HVAC Fans (Gas)	High Efficiency HVAC Fans	Standard Fan HVAC System	HVAC	Natural Gas	RET, ROB and NEW
Ind | High Efficiency Welders	High Efficiency Welders	Standard Efficiency Welders	Other Process	Electric	RET, ROB and NEW
Ind | High Efficiency Welders	High Efficiency Welders	Standard Efficiency Welders	Other Process	Electric	RET, ROB and NEW
Ind | HVLS Fans	HIGH VOLUME LOW SPEED FAN	2 units Box fan, 1 hp	Motors - Fans/Blowers	Electric	RET, ROB and NEW
Ind | HVLS Fans	HIGH VOLUME LOW SPEED FAN	2 units Box fan, 1 hp	Motors - Fans/Blowers	Electric	RET, ROB and NEW

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Ind | Low Energy Livestock Waterers	Low Energy Livestock Waterers	1,500 W (Max) electric heated Waterers	Other Process	Electric	RET, ROB and NEW
Ind | Boiler Tune-Up	Tuned Boiler	In Situ Boiler	Process Heating (Water and Steam)	Natural Gas	RET Only
Ind | Boiler Tune-Up - Direct	Tuned Boiler	In Situ Boiler	Process Heating (Direct)	Natural Gas	RET Only
Ind | Boiler Tune-Up - HVAC	Tuned Boiler	In Situ Boiler	HVAC	Natural Gas	RET Only
Ind | Low Energy Livestock Waterers	Low Energy Livestock Waterers	1,500 W (Max) electric heated Waterers	Other Process	Electric	RET, ROB and NEW
Ind | Material Handling Improvements	Material Handling Improvements	As is Material Handling System	Motors - Other	Electric	RET, ROB and NEW
Ind | Material Handling Improvements	Material Handling Improvements	As is Material Handling System	Motors - Other	Electric	RET, ROB and NEW
Ind | Premium Efficient Motors	Premium Efficient Motors	Standard Motors	Motors - Other	Electric	RET, ROB and NEW
Ind | Premium Efficient Motors	Premium Efficient Motors	Standard Motors	Motors - Other	Electric	RET, ROB and NEW
Ind | Process Optimisation (Gas)	Process Optimisation	Non-optimised process	Other Process	Natural Gas	RET Only
Ind | Steam Trap Repair	Steam Trap Survey/Monitoring System	No Monitoring System	Process Heating (Water and Steam)	Natural Gas	RET Only
Ind | Steam Leak Repairs	Steam Leak Repairs	Leaky Steam System	Process Heating (Water and Steam)	Natural Gas	RET Only
Ind | HE HVAC Units	High Efficiency HVAC Units	Standard HVAC Units	HVAC	Electric & Natural Gas	RET, ROB and NEW
Ind | HE HVAC Units	High Efficiency HVAC Units	Standard HVAC Units	HVAC	Electric & Natural Gas	RET, ROB and NEW
Ind | Pump Equipment Upgrade	Pump Equipment Upgrade	No Equipment Upgrade	Motors - Pumps	Electric	RET, ROB and NEW
Ind | Improved Controls -Process Heating Gas	Improved Controls - Process Heating	No Controls Installed	Process Heating (Direct)	Natural Gas	RET Only
Ind | Process Heat Recovery (Gas)	Process Heat Recovery	No Process Heat Recovery	Process Heating (Direct)	Natural Gas	RET Only
Ind | Process Heat Recovery (Gas) - HVAC	Process Heat Recovery	No Process Heat Recovery	HVAC	Natural Gas	RET Only
Ind | VAV Conversion Project (Gas)	VAV Conversion Project (Gas)	Constant Volume System	HVAC	Natural Gas	RET Only
Ind | Insulation - Steam	Insulation - Steam	No Insulation or Substandard Insulation	Process Heating (Water and Steam)	Natural Gas	RET Only
Ind | Insulation - Steam - Direct	Insulation - Steam	No Insulation or Substandard Insulation	Process Heating (Direct)	Natural Gas	RET Only

Measure Name	Measure Description	Baseline Assumption	End Use Category	Primary Utility Type	Replacement Type
Ind | Insulation - Steam (AG)	Insulation - Steam	No Insulation or Substandard Insulation	Process Heating (Water and Steam)	Natural Gas	RET Only
Ind | Insulation - Steam - HVAC	Insulation - Steam	No Insulation or Substandard Insulation	HVAC	Natural Gas	RET Only
Ind | Pump Equipment Upgrade	Pump Equipment Upgrade	No Equipment Upgrade	Motors - Pumps	Electric	RET, ROB and NEW
Ind | Pump System Optimisation	Pump System Optimisation	No Optimisation	Motors - Pumps	Electric	RET, ROB and NEW
Ind | Pump System Optimisation	Pump System Optimisation	No Optimisation	Motors - Pumps	Electric	RET, ROB and NEW
Ind | Recommissioning	Industrial Recommissioning	Site as is	All	Electric & Natural Gas	RET Only
Ind | Process Heat Improvements	Process Heat Improvements	Standard Process Heating	Process Heating (Direct)	Electric & Natural Gas	RET Only
Ind | Process Heat Improvements	Process Heat Improvements	Standard Process Heating	HVAC	Electric & Natural Gas	RET, ROB and NEW
Ind | Process Heat Improvements	Process Heat Improvements	Standard Process Heating	Process Heating (Direct)	Electric & Natural Gas	RET, ROB and NEW
Ind | Process Heat Improvements	Process Heat Improvements	Standard Process Heating	HVAC	Electric & Natural Gas	RET, ROB and NEW
Ind | Gas Turbine Optimisation	Gas Turbine Optimisation	No Optimisation	Other Process	Natural Gas	RET Only
Ind | Recommissioning	Industrial Recommissioning	Site as is	All	Electric & Natural Gas	RET Only
Ind | Refiner Plate Improvements	Pulp and Paper Refiner Improvements	Standard Refiner Plate	Motors - Pumps	Electric	RET, ROB and NEW
Ind | Refiner Plate Improvements	Pulp and Paper Refiner Improvements	Standard Refiner Plate	Motors - Pumps	Electric	RET, ROB and NEW
Ind | Steam Turbine Optimisation	Steam Turbine Optimisation	No Optimisation	Other Process	Natural Gas	RET Only
Ind | Refrigeration Compressor VFD	VFD on Compressor	Standard Compressor	Process Cooling	Electric	RET, ROB and NEW
Ind | Refrigeration Compressor VFD	VFD on Compressor	Standard Compressor	Process Cooling	Electric	RET, ROB and NEW
Ind | Greenhouse Curtains	Greenhouse Curtains	No Curtains	HVAC	Natural Gas	RET Only
Ind | Ventilation Optimisation	Ventilation Optimisation	No design optimisation	HVAC	Electric	RET, ROB and NEW
Ind | Ventilation Optimisation	Ventilation Optimisation	No design optimisation	HVAC	Electric	RET, ROB and NEW
Ind | Loading Dock Seals	Loading Dock Seals	No Seals	HVAC	Natural Gas	RET Only
Ind | Solar Walls	Solar Walls	Standard Building Walls	HVAC	Natural Gas	RET Only
Ind | Ventilation Optimisation (Gas)	Optimise Ventilation System	As is ventilation	HVAC	Natural Gas	RET Only

Source: Navigant analysis

C.1.2 Baseline Peak Demand Estimates for DR-Enabling Measures

The steps for developing the baseline peak demand estimates were as follows:

1. Mapped DR measures to end use load profiles (listed below)

Table C-7. Mapped End Use Profiles to DR-Enabling Energy Efficiency Measures

Sector	DR-Enabling Energy Efficiency Measure	Mapped End Use Load Profile
Residential	Adaptive Thermostats	End use load profiles not employed. Unit impacts drawn directly from IESO impact evaluation report (see below).
	Variable Speed Pool Pump Motors	
Commercial	Adaptive Thermostats	End use load profiles not employed. Unit impacts drawn directly from IESO impact evaluation report (see below).
	Advanced BAS Controllers	Load profile is an average of both Space Cooling and HVAC Fans/Pumps IESO load profiles since the BAS controller influences both. Average weighted by end use consumption.
	Central Lighting Control Systems	Used Lighting_Interior_General IESO load profile.
	Networked/Connected- High Impact Application	
	Networked/Connected – Low Impact Application	

Source: Navigant analysis

2. Applied the peak period definition for DR to the end use load profiles to derive the average coincident peak demand factor for the EE measures.
3. Multiplied the average coincident peak demand factor with the energy use (kWh) associated with the EE measure to calculate the average coincident peak demand (kW) for the EE measure.

C.1.3 Unit Impact Estimates for DR-Enabling Technologies

The following assumptions and sources were used for unit impact estimates for the DR measures:

Table C-8. Residential Unit Impact Assumptions

Sector	DR-Enabling Energy Efficiency Measure	Assumed Unit Impact	Basis/Source
Residential	Adaptive Thermostats	0.378 kW reduction per thermostat	*Source: peaksaverPLUS® Program 2014 Load Impact Evaluation; August 2015; Prepared for Independent Electricity System Operator; Prepared by Nexant.* Used average ex ante peak period load impact for residential CAC load control under normal weather conditions (Table 1-2);

Sector	DR-Enabling Energy Efficiency Measure	Assumed Unit Impact	Basis/Source
	Variable Speed Pool Pump Motors	0.33 kW reduction per pump	*Source: peaksaverPLUS® Program 2014 Load Impact Evaluation; August 2015; Prepared for Independent Electricity System Operator; Prepared by Nexant.* Used average ex ante load impacts for pool pumps over the DR event window (Table 3-14);

Source: Navigant analysis

Table C-9. Commercial Unit Impact Assumptions

Sector	DR-Enabling Energy Efficiency Measure	Assumed Unit Impact	Basis/Source
Commercial	Adaptive Thermostats	0.394 kW reduction per thermostat	*Source: peaksaverPLUS® Program 2014 Load Impact Evaluation; August 2015; Prepared for Independent Electricity System Operator; Prepared by Nexant.* Used average ex ante peak period load impact for small commercial CAC load control under normal weather conditions (Table 1-2);
	Advanced BAS Controllers	66% of baseline peak demand	Unit impact assumes Automated DR for control of HVAC load; sourced from Lawrence Berkeley National Lab developed assumptions for HVAC impacts using Auto-DR from the 2017 California Demand Response Potential Study Phase II Appendix (*Source: Phase 2 Appendices; California Demand Response Potential Study; November 14, 2016*).
	Central Lighting Control Systems	• 22% of baseline peak demand (for all segments other than Large Office, Other Office, and Other Commercial) • 28% of baseline peak demand (for Large Office, Other Office, and Other Commercial segments)	Unit impact for DR assumes central lighting controls; sourced from Lawrence Berkeley National Lab developed assumptions for lighting control impacts from the 2017 California Demand Response Potential Study Phase II Appendix *(Source: Phase 2 Appendices; California Demand Response Potential Study; November 14, 2016).*

Sector	DR-Enabling Energy Efficiency Measure	Assumed Unit Impact	Basis/Source
	Networked/Connected - High Impact Application	• 55% of baseline peak demand (for all segments other than Large Office, Other Office, and Other Commercial) • 72% of baseline peak demand (for Large Office, Other Office, and Other Commercial segments)	Unit impact for DR assumes luminaire level controls; sourced from Lawrence Berkeley National Lab developed assumptions for lighting control impacts from the 2017 California Demand Response Potential Study Phase II Appendix *(Source: Phase 2 Appendices; California Demand Response Potential Study; November 14, 2016).*

Source: Navigant analysis

C.1.4 DR Potential for the Measures

Navigant used two approaches for estimating DR potential of adopted EE measures. These are described below.

Direct Method: Where unit impact values were available as kW reduction from empirical evaluations of local pilots or programs, these were applied directly to the appropriate scaling factor. This method applied to the following measures:

Residential DR-enabling technologies

- Adaptive Thermostats
- Variable Speed Pool Pump Motors

Commercial DR-enabling technologies

- Adaptive Thermostats

Under this method, the DR potential is calculated as follows:

DR Potential = *Unit Impact from controlled equipment (kW reduction) x*
No. of control equipment per household (density) x
% of households with the control equipment (saturation) x
Total number of households

Derived Method: Where direct unit impacts are not available for Ontario, unit impacts are derived based on estimated end use consumption and percent reduction in end use load factors. Derived unit impacts are then applied to the appropriate scaling factor. This method applied to the following measures:

Commercial DR-enabling technologies

- Advanced BAS Controllers
- Central Lighting Control Systems
- Networked/Connected- High Impact Application
- Networked/Connected – Low Impact Application

Under this method, the DR potential is calculated as follows:

DR Potential = *Coincident Peak Demand for controlled end use (kW) x*

Unit Impact from controlled end use (average % load reduction during a DR event) x No. of control equipment per sq. ft.(density) x % of buildings with the control equipment (saturation) x Total number of households.

C.1.5 Input and Cost Sources

Navigant used NRCan and StatsCan data, US DOE Appliance Standards and Rulemakings supporting documents, and US Northwest Regional Technical Forum (RTF) measure workbooks.

Navigant used engineering algorithms to calculate energy savings for any measures not included in available TRMs, and internal expertise and experience with potential studies to calculate the energy savings.

The source of inputs to the algorithm was decided based on most recent and relevant source for Ontario measures. The list below details all sources used for developing savings estimates:

- IESO 2019 MAL
- ON EM&V Reports
- NRCan
- StatsCan
- Weather data from the Government of Canada
- US DOE
- Northwest (US) Power and Conservation Council's RTF
- ENERGY STAR Standards
- TRMs from Illinois, Pennsylvania, Minnesota, and Massachusetts
- OEB TRM 2019
- Michigan Measures Energy Database (MEMD)
- 2016 Natural Gas Conservation Potential Study and 2016 Achievable Potential Study
- British Columbia, Sask Power, Alberta and Ontario Potential Study data
- US IAC database
- Pacific Northwest National Laboratory data
- Xcel Colorado, NGRID, Pennsylvania Potential Study.

Navigant derived costs for baseline and efficiency measures based on the most recent and relevant data for Ontario. The following sources were used to derive measure costs:

- IESO 2019 MAL
- ON EM&V Reports
- Canadian Retail Websites
- NRCan
- US DOE
- Northwest (US) Power and Conservation Council's RTF
- TRMs from Illinois, Minnesota, and Massachusetts
- OEB TRM 2019
- Michigan Measures Energy Database (MEMD)
- Database of Energy Efficiency Resources (DEER)
- 2016 Natural Gas Conservation Potential Study and 2016 Achievable Potential Study
- Itron Ex Ante Cost Study
- Recent British Columbia, Sask Power, Alberta and Ontario Potential Studies
- US IAC database

C.1.6 Industrial Measures

IAC[103] follows a standard process for auditing industrial sites and collecting all the relevant information about their equipment inventory. During a 1- or 2-day audit, the IAC team identifies potential energy efficiency measures that could be implemented at the site. The measures are identified based on IAC member expertise, and a detailed audit of the site equipment. The measures identified vary from site to site based on the individual site operation, opportunities and equipment present at the site. The IAC team members identify a list of measures and decide what measures should be investigated further. At this point, measures may be removed from the list only due to lack of applicability and actual installation concerns (i.e., technically infeasible recommendations are dropped). Once the measures have been finalised, the IAC team members then collect data related to these measures during the audit in order to further investigate savings potential and cost for these measures.

---

[103] Office of Energy & Renewable Energy, Industrial Assessment Centers (IACS), https://www.energy.gov/eere/amo/industrial-assessment-centers-iacs

Appendix D. TECHNICAL POTENTIAL

This appendix provides additional detail regarding the estimation of technical potential. It is divided into two main sections:

1. **Detailed Approach and Methodology:** Expands on descriptions of the approach to estimating technical potential highlighted in Chapter 5
2. **Results (Expanded):** Expands on the results provided in the body of Chapter 5, providing additional granularity of results.

D.1 Detailed Methodology

D.1.1 Measure Stacking

As noted above, to calculate the potential resulting from considering measure stacking (Stacked Potential), the unadjusted potential (Unstacked Potential) is reduced by a combination of how often stacking measures are installed in the same building (Stacking Frequency), and the reduced savings achieved when installing measures that stack (Savings Adjustment) as seen in Equation D-1.

Equation D-1. Potential after Stacking Calculation

$$Stacked\ Potential = Unstacked\ Potential\ x\ (1 - \ Savings\ Adjustment\ x\ Stacking\ Frequency)$$

Source: Navigant analysis

The Savings Adjustment and Stacking Frequency factors had their own group of assumptions and estimations which are as follows:

Segment-End Use Savings Adjustment

1. Total potential is aggregated by segment, end use, year, and measure-type (engine/envelope), and divided by stock to deliver an end use savings intensity.
2. This is divided by the reference forecast intensity for that segment's end use in the same year to give a percentage savings value for each segment, end use, and year combination for both engine and envelope measures.
3. The total percentage savings that would be achieved if all measures are stacked is calculated as: $Stacked\ Savings\ =\ \%\ Engine\ Savings\ +\ (1 - \%\ Engine\ Savings)\ x\ \%\ Envelope\ Savings$
4. The factor that needs to be applied to unstacked potential to deliver stacked potential (i.e., the stacked savings adjustment, if all measures are stacked) is calculated as:

$$Savings\ Adjustment = \frac{Stacked\ Savings}{Total\ Unadjusted\ Savings}$$

The measures stacking frequency value is used to account for the fact that not all measures get stacked, but some do.

Measure Stacking Frequency

1. Stacking Frequency will take a distinct value for each year, and for each unique segment and end use combination.
2. The measure stacking frequency calculation assumes that the distribution of each measure's adoption is independent of other measures' adoption distribution. Specifically:
    a. It assumes, for example, that the probability of an individual installing a lighting controller is unaffected by whether or not that individual has also installed an efficient lamp. This is a simplifying assumption as data was not accessible to support making a decision otherwise.
    b. It is possible that the distributions may be positively correlated (in the case of a major house renovation which could see an upgrade of both insulation beyond code and a furnace beyond code), or negatively correlated (a homeowner or business buying an above-code furnace may not wish to go to the extra expense of above code insulation, understanding the diminishing returns at play). Generating sufficiently concrete evidence to make a claim to one or the other effect is beyond the scope of this study.
3. Measure stacking frequency in any given year, for each segment/end use pair is calculated as the product of the:
    a. Total saturation in the given year of engine measures in the given segment/end use pair
    b. Total saturation in the given year of the envelope measures in the given segment/end use pair
4. In many cases the calculation of total saturation is a simple sum across the relevant measure type (engine or envelope). This is true when, for the given measure type (engine or envelope) there is only a single competition group within the end use. Where multiple competition groups exist within an end use, (e.g., insulation vs. windows), an additional calculation is required.
    a. Within each segment, end use, year, and measure-type (engine/envelope) total saturation values are summed up *by competition group*. This captures the overall percentage of the given equipment type that has been replaced by a more efficient measure.
    b. At this point, saturation-weighted average measure savings (or total provincial measure savings) are calculated for each competition group
    c. Measure-type (engine/end use) overall saturation by segment, end use, and year is *the average of the saturations across the competition groups*, weighted by the average (or total) competition group savings output immediately above.

The Savings Adjustment is then multiplied by the Stacking Frequency to deliver the final year, segment, and end use specific savings adjustment (as a percentage value).

D.1.2 Fuel Switching

This study evaluated the potential within the province for switching to the consumption of electricity from the consumption of natural gas. Navigant calculated the fuel switching potential for electric measures that replace natural gas space and water heating measures in the commercial and residential sectors.

In the energy efficiency (EE) potential estimation context, the savings considered in technical potential are those of the primary fuel type (e.g., electricity for light bulbs). However, in the fuel switching context, all primary fuel consumption (natural gas) is reduced to zero as it switches to consuming a different fuel (in this case, electricity). Thus, for the purposes of this report, fuel switching technical potential refers to the total increase in electricity use (i.e., negative savings) associated with measures that switch from natural gas to electricity use. This is also referred to as the electrification potential.

To avoid confounding the question of potential attribution, the technical potential for fuel switching was estimated in isolation from the technical potential associated with energy conservation measures. Effectively, these are two independent analyses of potential – no competition between fuel switching technologies and standard energy efficiency measures is assumed.

D.1.3 Technically Feasible Demand Response

This study evaluated the potential within the province for measures that are eligible to participate in demand response programs. Specifically, the demand response potential of the measures that were adopted as part of the energy efficiency program is assessed; no separate modelling of demand response programs was performed.

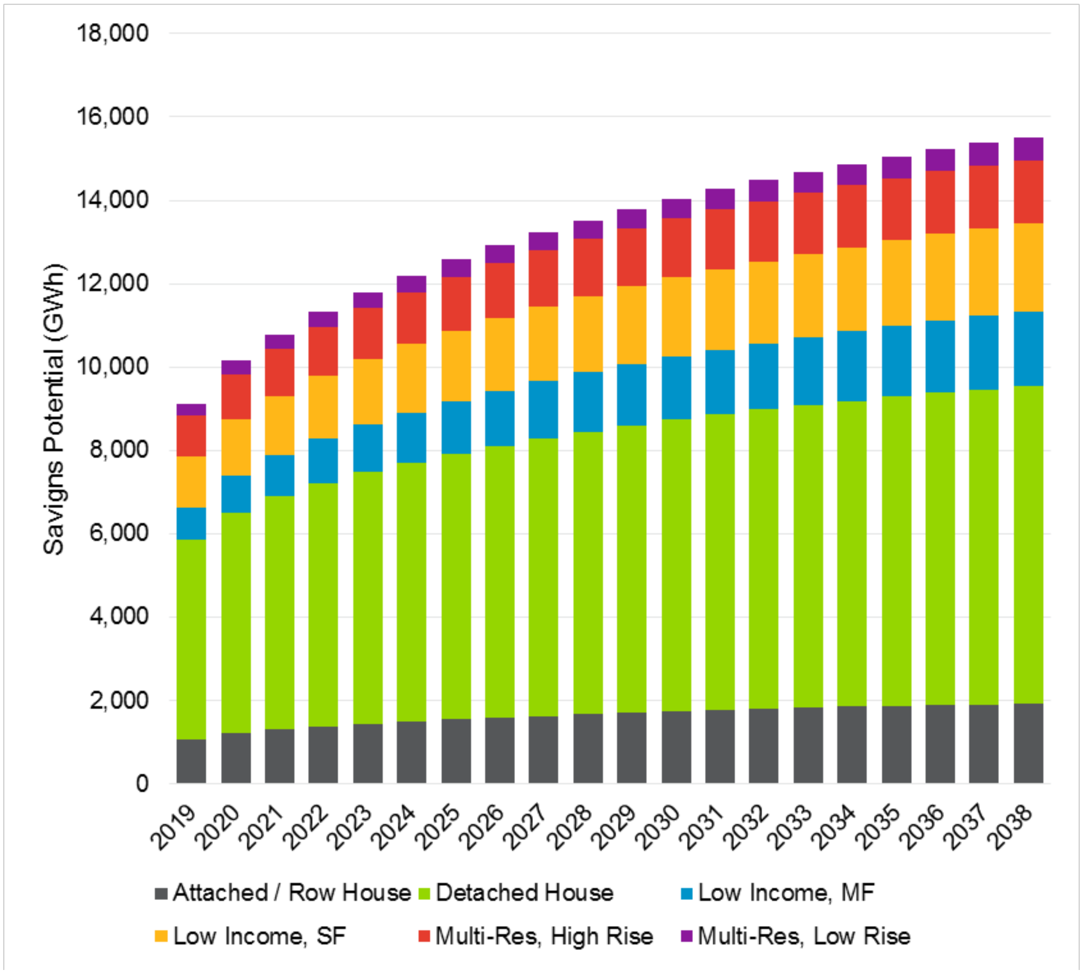
The estimation of DR potential was calculated as described in Chapter 4.

D.2 Results (Expanded)

D.2.1 Energy Efficiency Potential

The following charts show the energy efficiency technical potential by customer segment. Figure D-1 shows the electric energy technical potential across all residential customer segments. As is quite common, the detached house customer segment represented the largest savings potential of any customer segment by a large margin, more than tripling the potential of any other customer segment. This is largely due to there being much greater forecast sales for this segment as compared to the others.

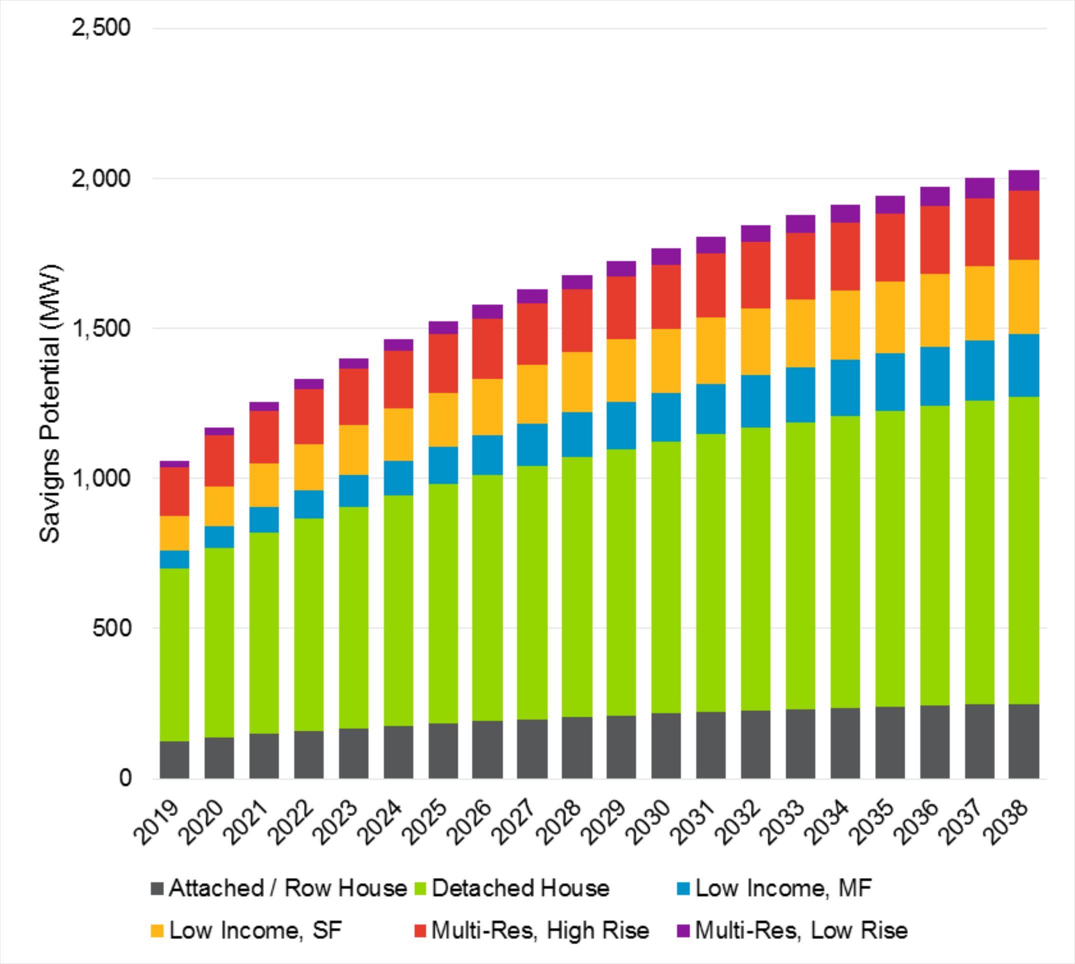
Figure D-1. Residential Electric Energy Technical Potential by Customer Segment (GWh)



Source: Navigant analysis

Figure D-2 shows the electric demand technical potential across all residential customer segments.

Figure D-2. Residential Electric Demand Technical Potential by Customer Segment (MW)

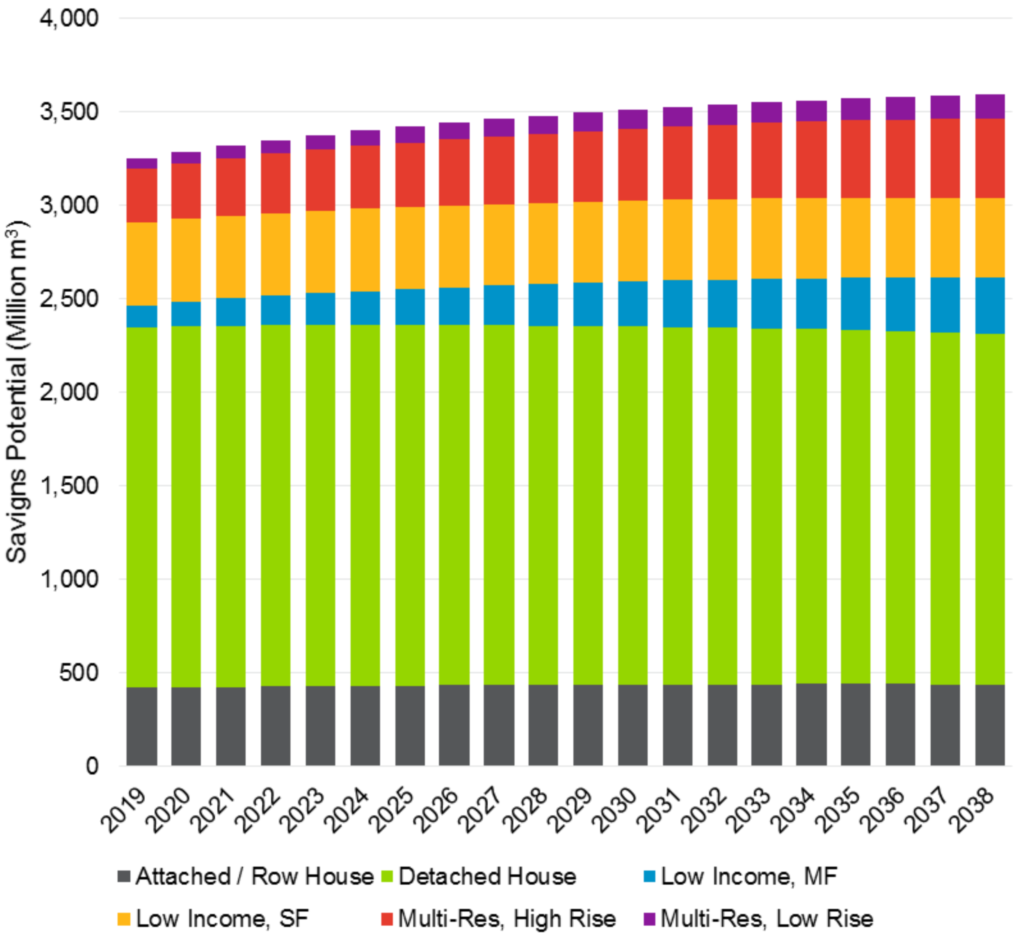


Source: Navigant analysis

When comparing the electric demand potential to the electric energy potential, there is almost no noticeable difference with respect to the spread of potential across customer segments.

Figure D-3 shows the natural gas energy technical potential across all residential customer segments. Similar to the electric energy potential, the detached house customer segment represented the largest savings potential of any customer segment by a large margin, again more than tripling the potential of any other customer segment. This is largely due to there being much greater forecast sales for this segment as compared to the others.

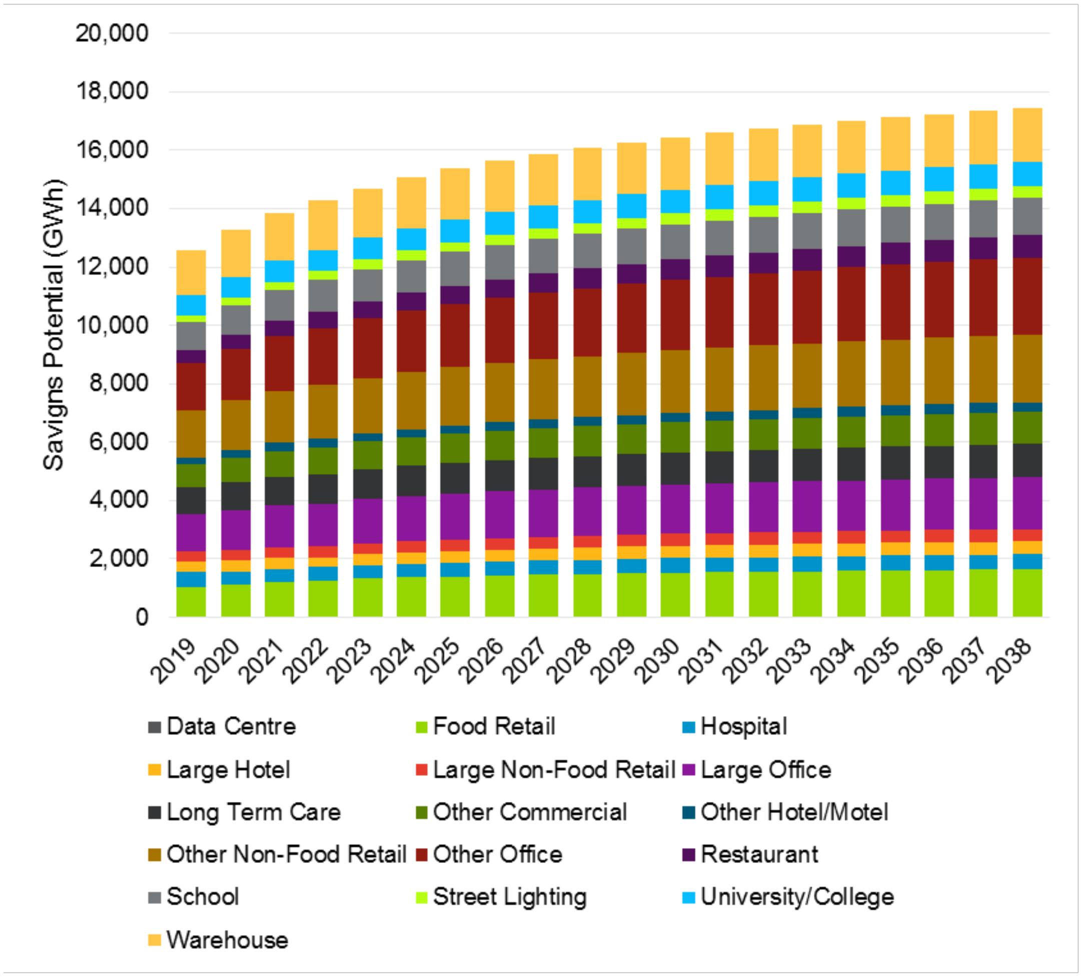
Figure D-3. Residential Natural Gas Energy Technical Potential by Customer Segment (Million m^3)



Source: Navigant analysis

Figure D-4 shows the electric energy technical potential across all commercial customer segments. The savings potential for the commercial sector was distributed more evenly across each of the customer segments. Specifically, the other office, other non-food retail, warehouse, and large office segments combine to account for approximately 50% of the total potential in a given year.

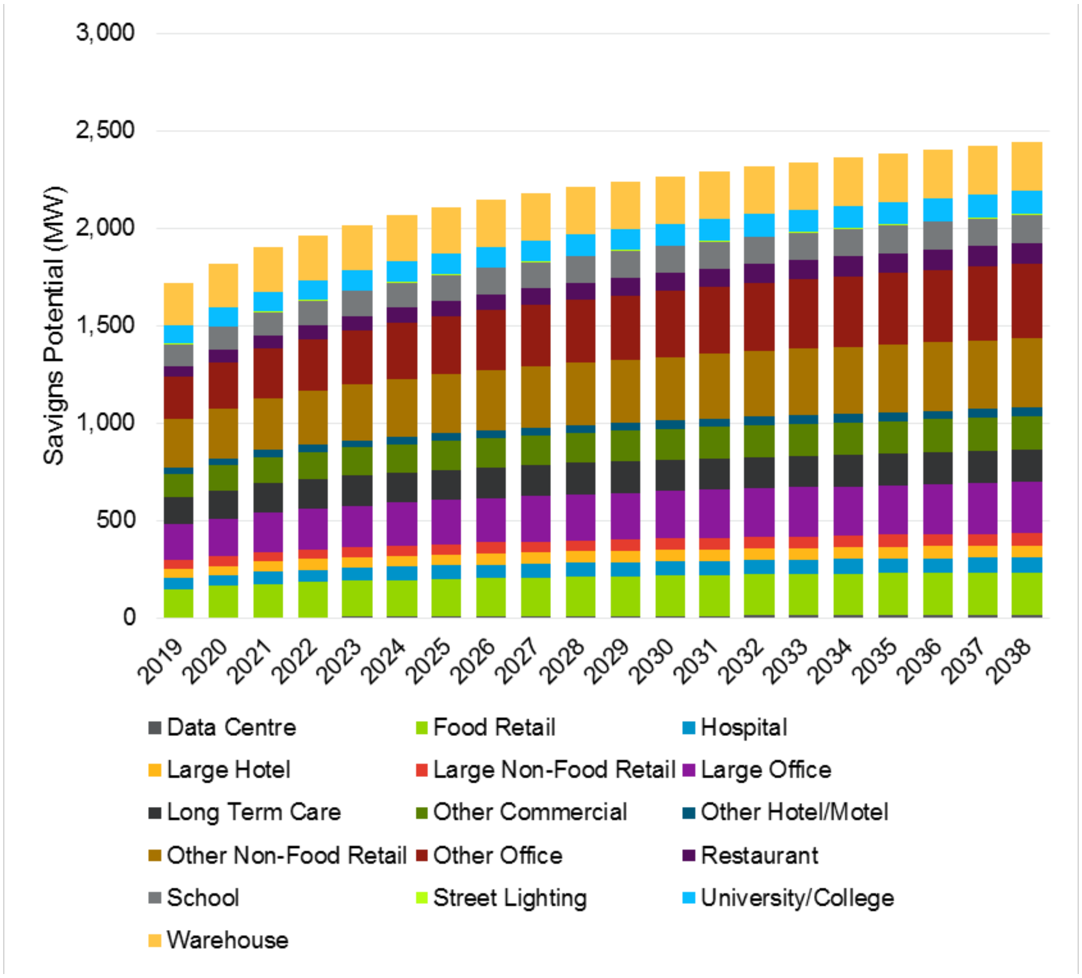
Figure D-4. Commercial Electric Energy Technical Potential by Customer Segment (GWh)



Source: Navigant analysis

Figure D-5 shows the electric demand technical potential across all commercial customer segments.

Figure D-5. Commercial Electric Demand Technical Potential by Customer Segment (MW)

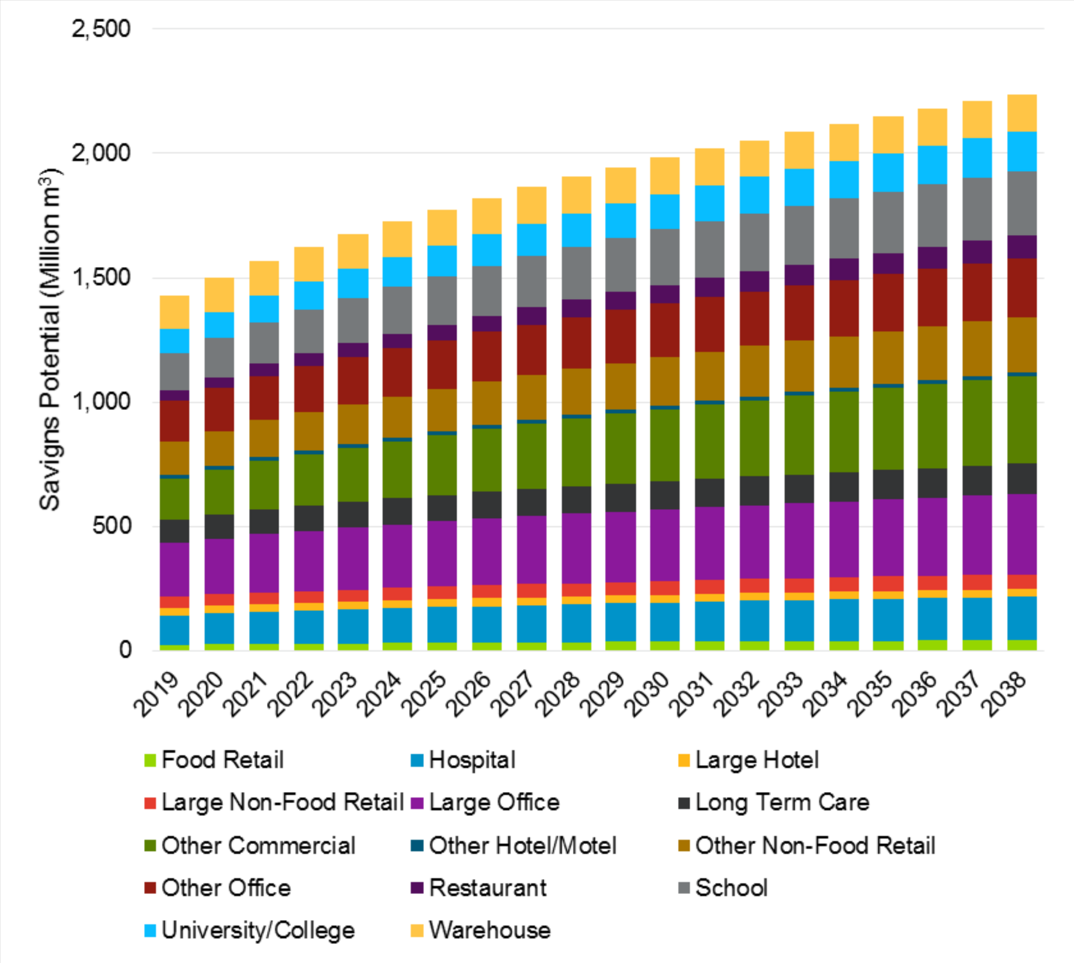


Source: Navigant analysis

When comparing the electric demand potential to the electric energy potential, there is almost no noticeable difference with respect to the spread of potential across customer segments except when comparing the street lighting customer segment. There is almost electric demand potential for this segment due to the fact that only a small percentage of its consumption aligns with the peak period.

Figure D-6 shows the natural gas energy technical potential across all commercial customer segments. Similar to the electric energy potential, the savings potential for the commercial sector was distributed more evenly across each of the customer segments. Specifically, the large office, other commercial, other office, and other non-food retail segments combine to account for approximately 50% of the total potential in a given year.

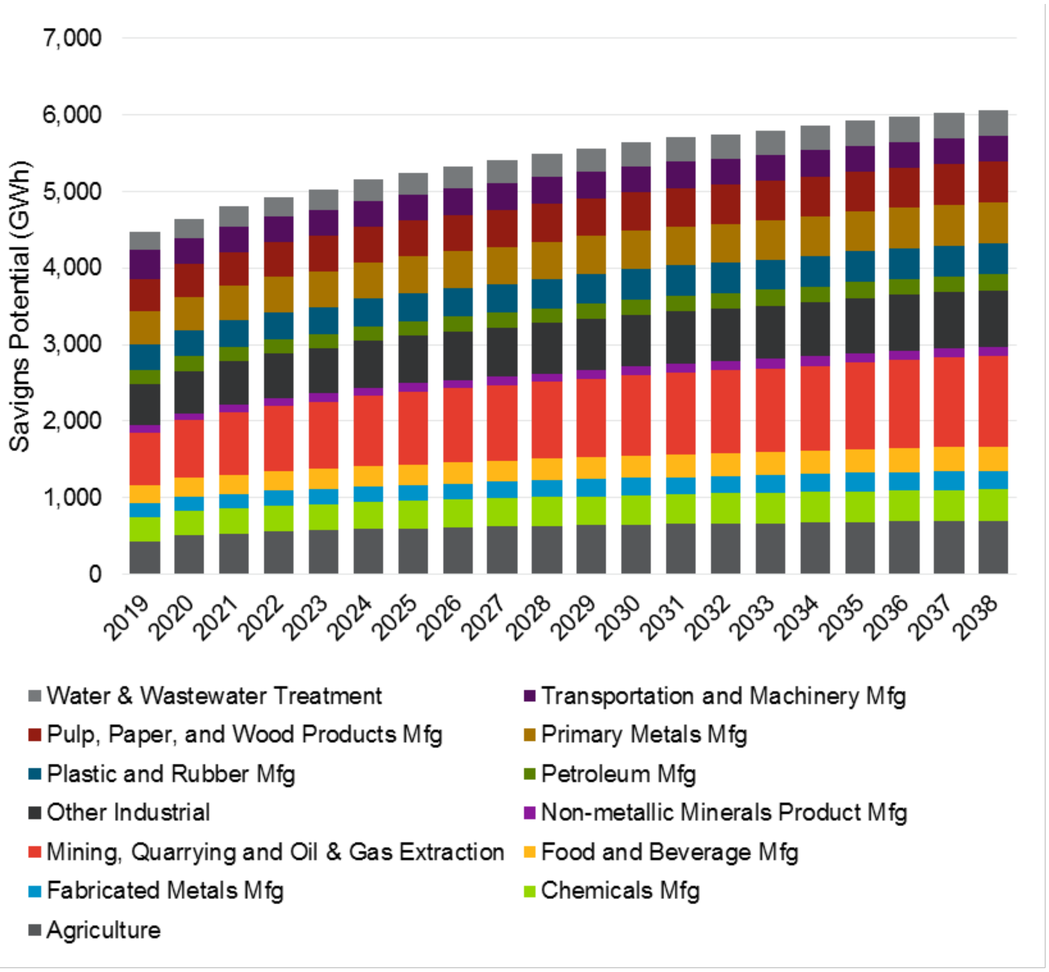
Figure D-6. Commercial Natural Gas Energy Technical Potential by Customer Segment (Million m^3)



Source: Navigant analysis

Figure D-7 shows the electric energy technical potential across all industrial customer segments. The savings potential for the industrial sector was distributed relatively evenly across each of the customer segments. Specifically, mining quarrying and oil & gas extraction, other industrial, agriculture, and primary metals manufacturing segments combine to account for approximately 50% of the total potential in a given year.

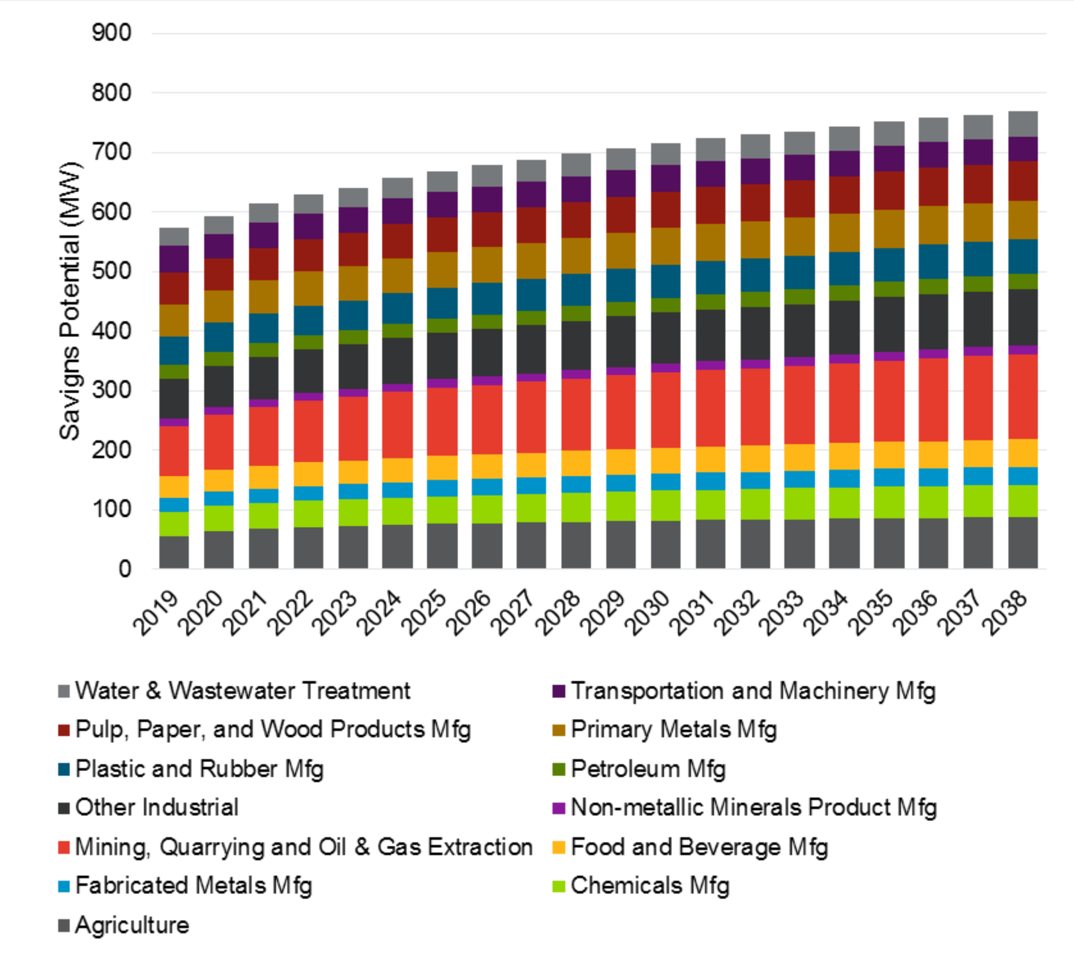
Figure D-7. Industrial Electric Energy Technical Potential by Customer Segment (GWh)



Source: Navigant analysis

Figure D-8 shows the electric demand technical potential across all industrial customer segments.

Figure D-8. Industrial Electric Demand Technical Potential by Customer Segment (MW)

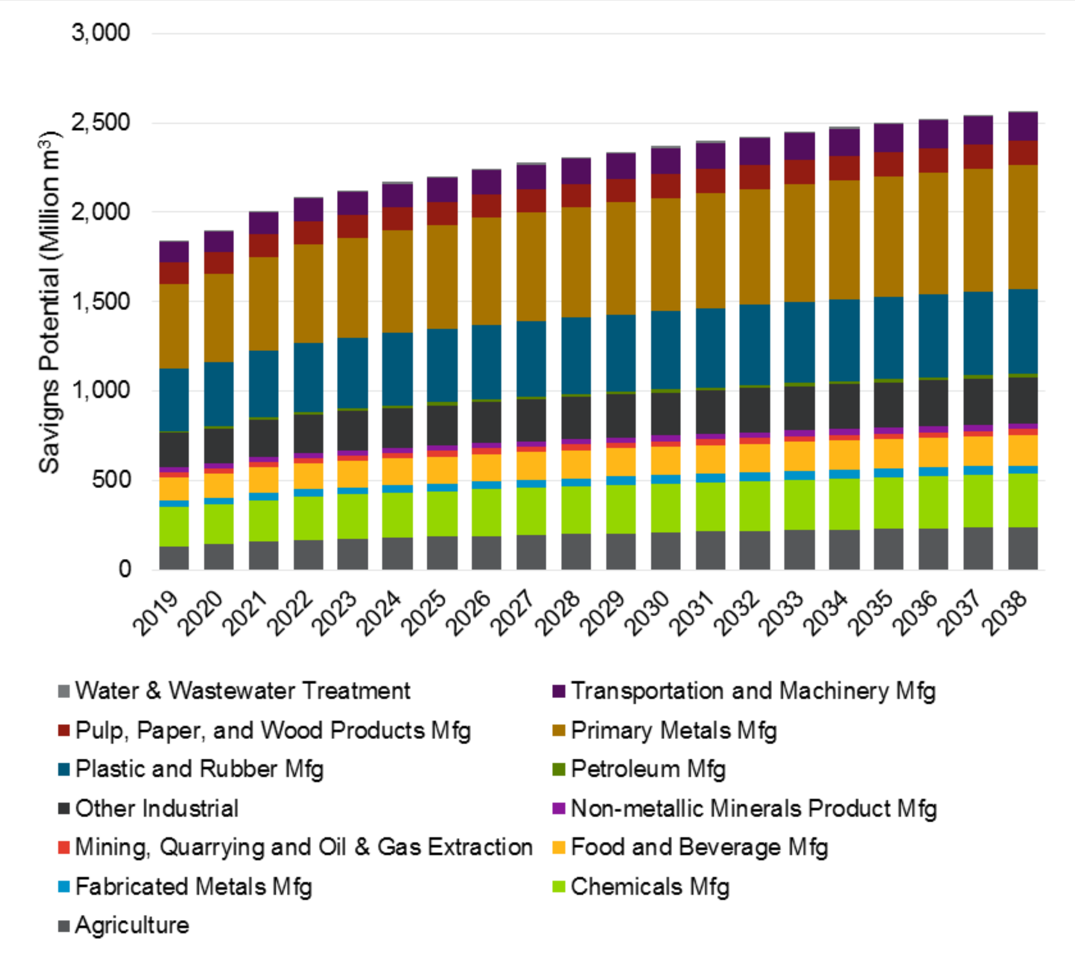


Source: Navigant analysis

When comparing the electric demand potential to the electric energy potential, there is almost no noticeable difference with respect to the spread of potential across customer segments.

Figure D-9 shows the natural gas energy technical potential across all industrial customer segments. As compared to the electric potential, the natural gas savings potential for the industrial sector was weighted more heavily to a select few segments. Specifically, primary metals manufacturing, plastic and rubber manufacturing, and chemicals manufacturing segments combined to account for more than 50% of the total potential in a given year.

Figure D-9. Industrial Natural Gas Energy Technical Potential by Customer Segment (Million m^3)

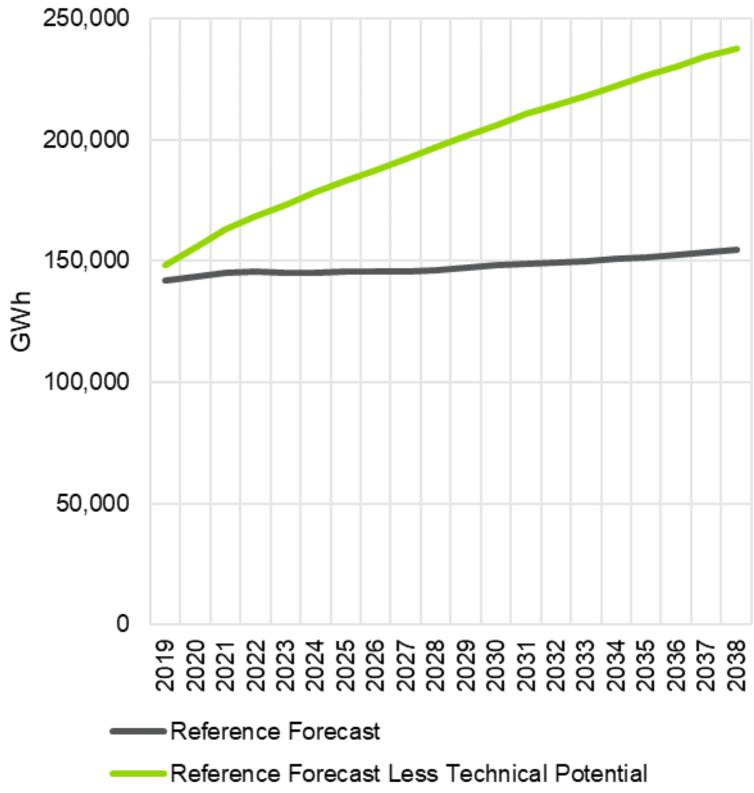


Source: Navigant analysis

D.2.2 Fuel Switching Potential

Figure D-10 contrasts the estimated technical electrification potential across the potential reference forecast period with the total forecast consumption over the same period.

Figure D-10. Electric Energy Reference Forecast and Technical Electrification Potential

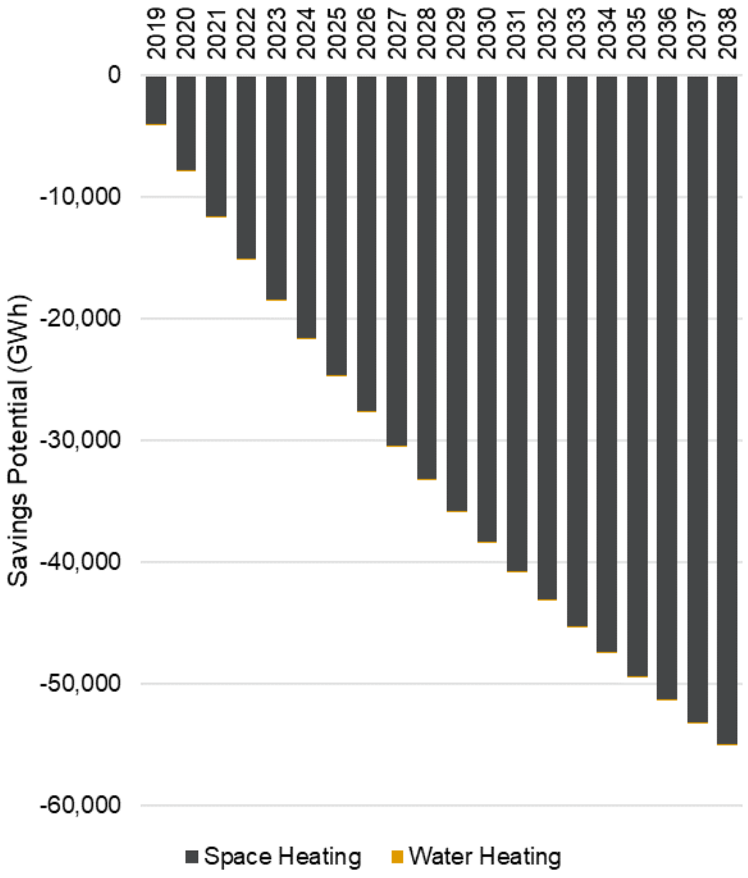


Source: Navigant analysis

The green line (reference forecast less technical potential) growing positively away from the black line (reference forecast) indicates that there will be a significant increase in electricity consumption as a result of fuel switching. This growth in electric consumption is to be expected as the mode of fuel switching considered in this study is replacing natural gas burning equipment with those that consume electricity.

Figure D-11 shows the electric energy technical electrification potential across the applicable residential end uses. The space heating end use accounts for nearly all of the residential sector's electrification potential. This is largely due to residential water heaters not being characterised as part of the fuel switching analysis. The exclusion of water heaters from the fuel switching characterisation was due to knowing that the measures would not be cost-effective, given the already relatively high efficiency of baseline gas water heaters allowing for lower claimed savings, and the high cost of the electric water heaters. This does not mean the technology has no electrification potential in the field; it simply means it was not captured as part of this study.

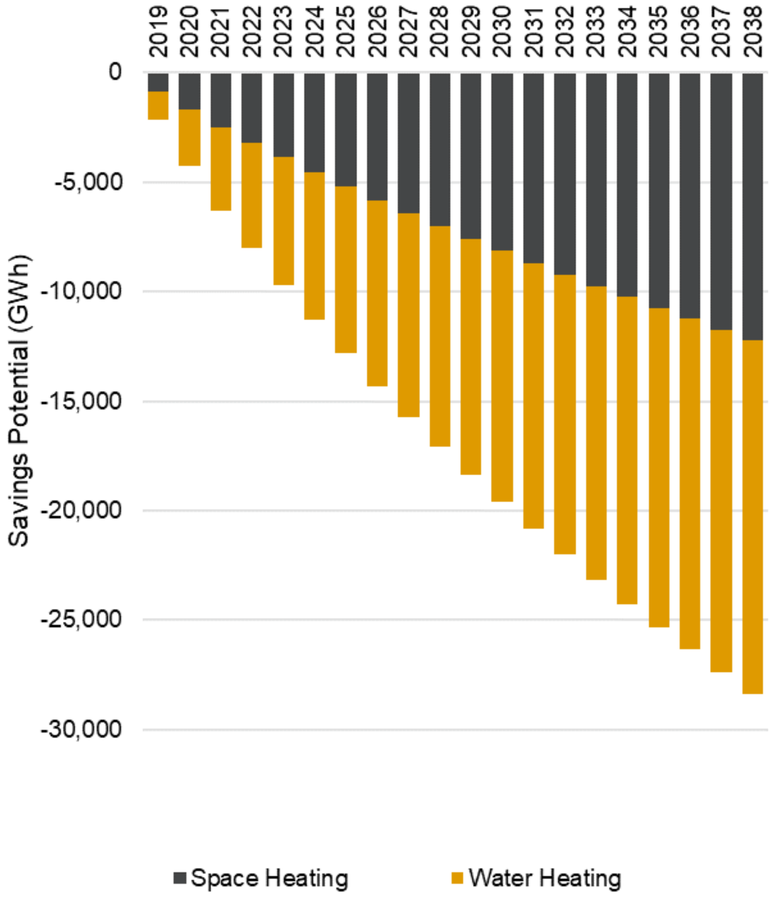
Figure D-11. Residential Electric Energy Technical Fuel Switching Savings Potential by End Use (GWh)



Source: Navigant analysis

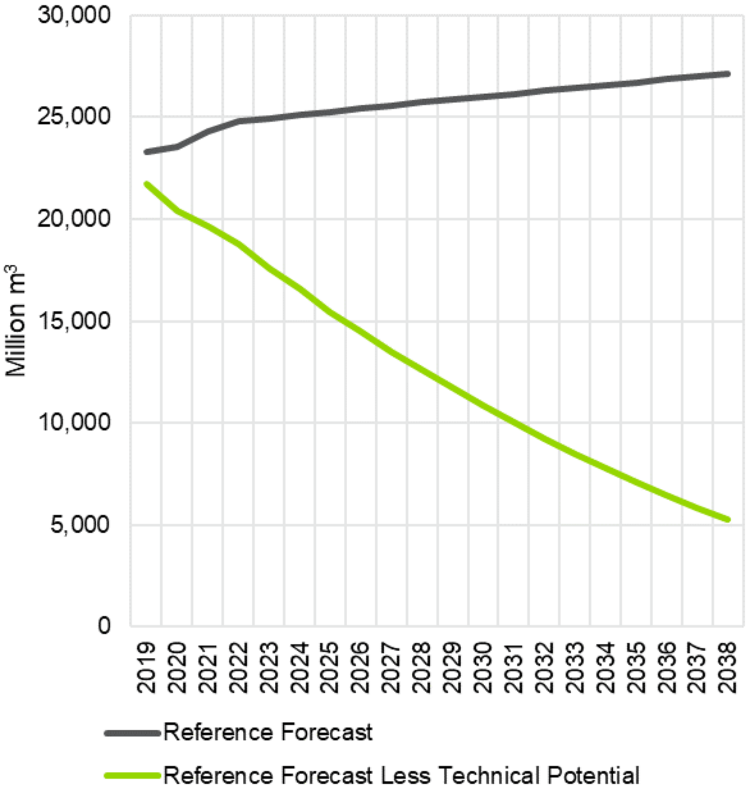
Figure D-12 shows the electric energy technical electrification potential across the applicable commercial end uses. The water heating end use accounts for a slight majority of the commercial sector's electrification potential.

Figure D-12. Commercial Electric Energy Technical Fuel Switching Savings Potential by End Use (GWh)



Source: Navigant analysis

Figure D-13. Natural Gas Reference Forecast and Fuel Switching Technical Potential (Million m^3)

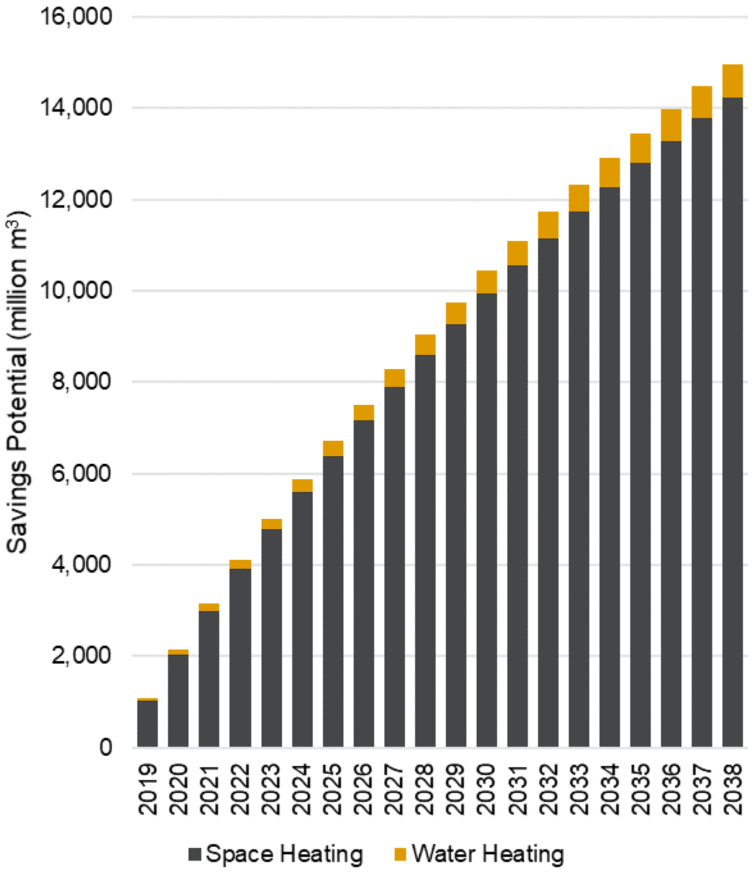


Source: Navigant analysis

The green line (reference forecast less technical potential) falling significantly below the black line (reference forecast) indicates significant potential for fuel switching, with a potential decrease of 30% in 2023, 58% in 2030, and 81% in 2038. This decrease in natural gas consumption is to be expected as the mode of fuel switching considered in this study is replacing natural gas burning equipment with those that consume electricity, meaning in each case, 100% of a given technology's natural gas consumption will be saved. Since these savings are in the space heating and water heating end uses which account for the majority of the natural gas consumption, it is reasonable that replacing the majority of these end uses' consumption would result in the dramatic savings you see in Figure D-13.

Figure D-14 shows the natural gas technical fuel switching potential across the applicable residential end uses. Again, the space heating end use accounts for nearly all of the residential sector's fuel switching potential. This is largely due to residential water heaters not being characterised as part of the fuel switching analysis. The exclusion of water heaters from the fuel switching characterisation was due to knowing that the measures would not be cost-effective, given the already relatively high efficiency of baseline gas water heaters allowing for lower claimed savings, and the high cost of the electric water heaters. This does not mean the technology has no electrification potential in the field, it simply means it was not captured as part of this study.

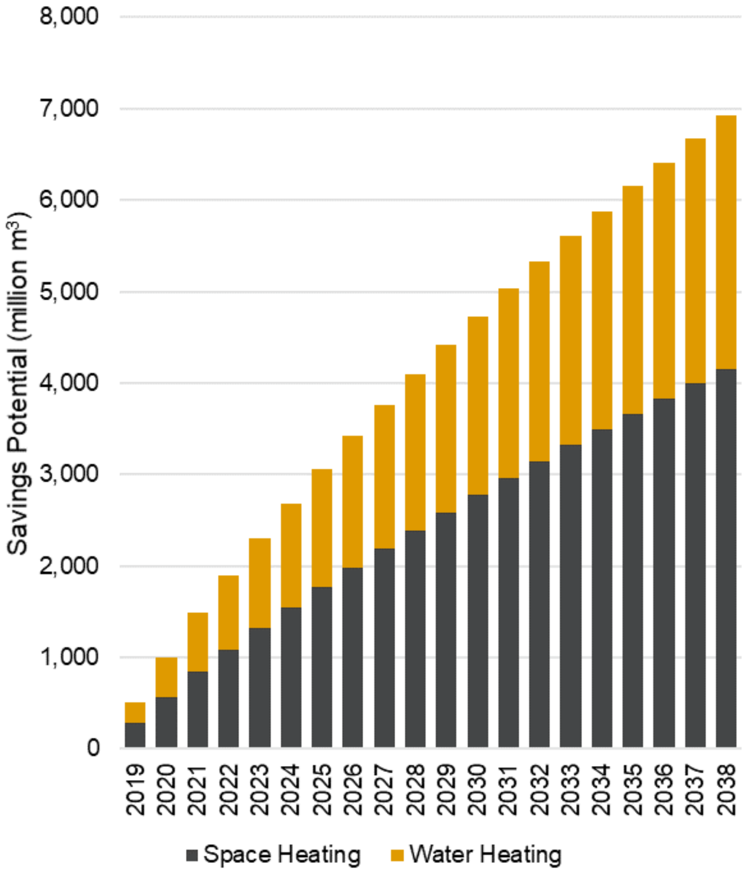
Figure D-14. Residential Natural Gas Technical Fuel Switching Savings Potential by End Use (Million m^3)



Source: Navigant analysis

Figure D-15 shows the natural gas technical fuel switching potential across the applicable commercial end uses. The space heating end use accounts for the majority of the commercial sector's electrification potential.

Figure D-15. Commercial Natural Gas Technical Fuel Switching Savings Potential by End Use (Million m^3)

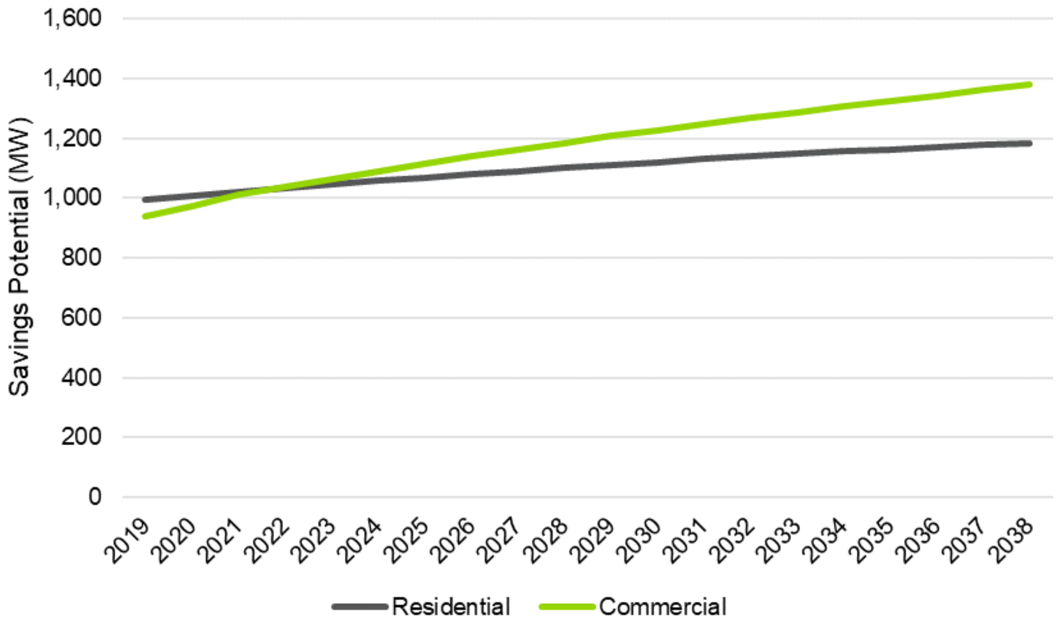


Source: Navigant analysis

D.2.3 Technically Feasible Demand Response

Figure D-16 shows the estimated technical electric demand response potential across the potential reference forecast period for each sector. The residential potential overshadowing that of the commercial sector is due to the selection of measures characterised as demand response eligible for each sector, and more of the measures in the residential sector being associated with space cooling and thus summer peak demand.

Figure D-16. Electric Demand Response Technical Potential by Sector (MW)



Source: Navigant analysis

Appendix E. ECONOMIC POTENTIAL

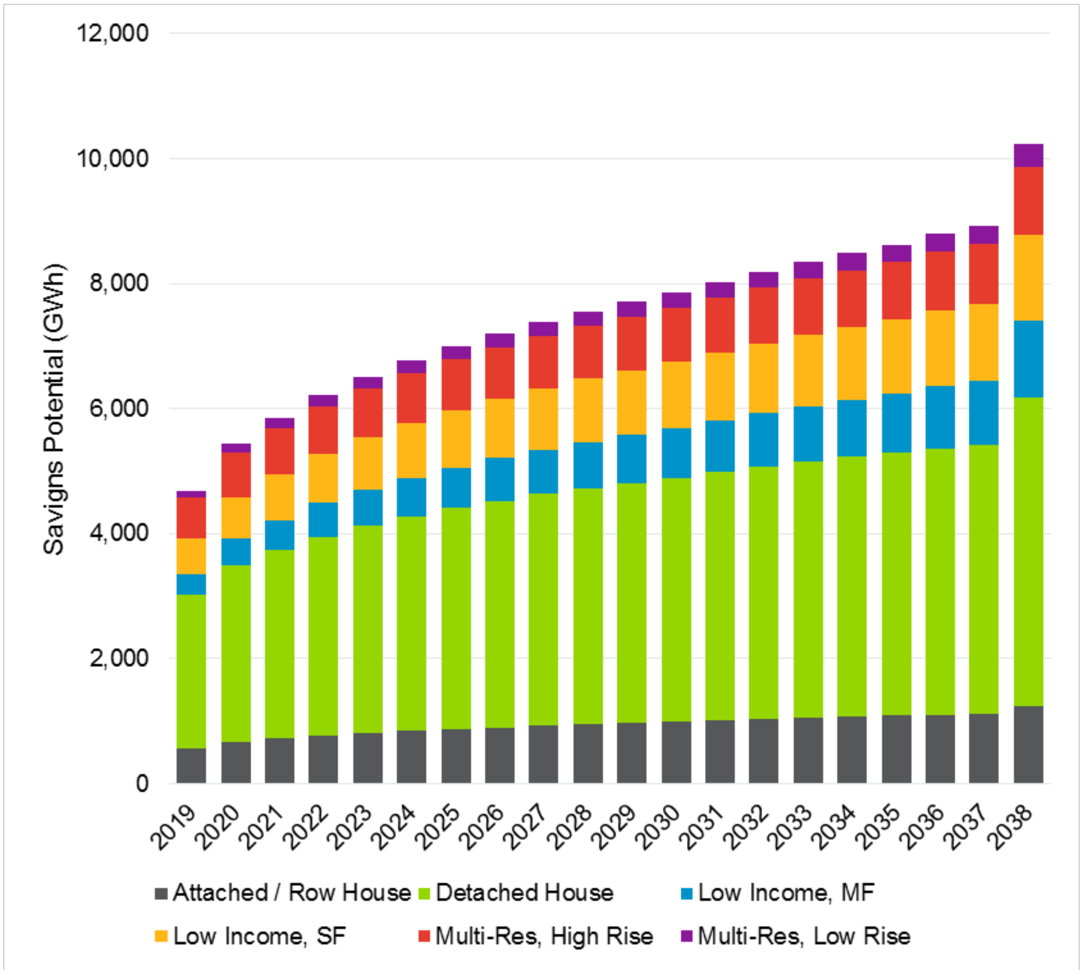
This appendix provides additional detail regarding the estimation of economic potential. It expands on the results provided in Chapter 6, including additional granularity of results.

E.1 Results (Expanded)

E.1.1 Customer Segment

Figure E-1 shows the electric energy economic potential across all residential customer segments. The general trend of each customer segment's potential follows that seen in technical potential with the main difference seen with respect to the detached house customer segment. This was the result of the smart power bar not being cost-effective for all years except 2038, where you see the economic potential jump.

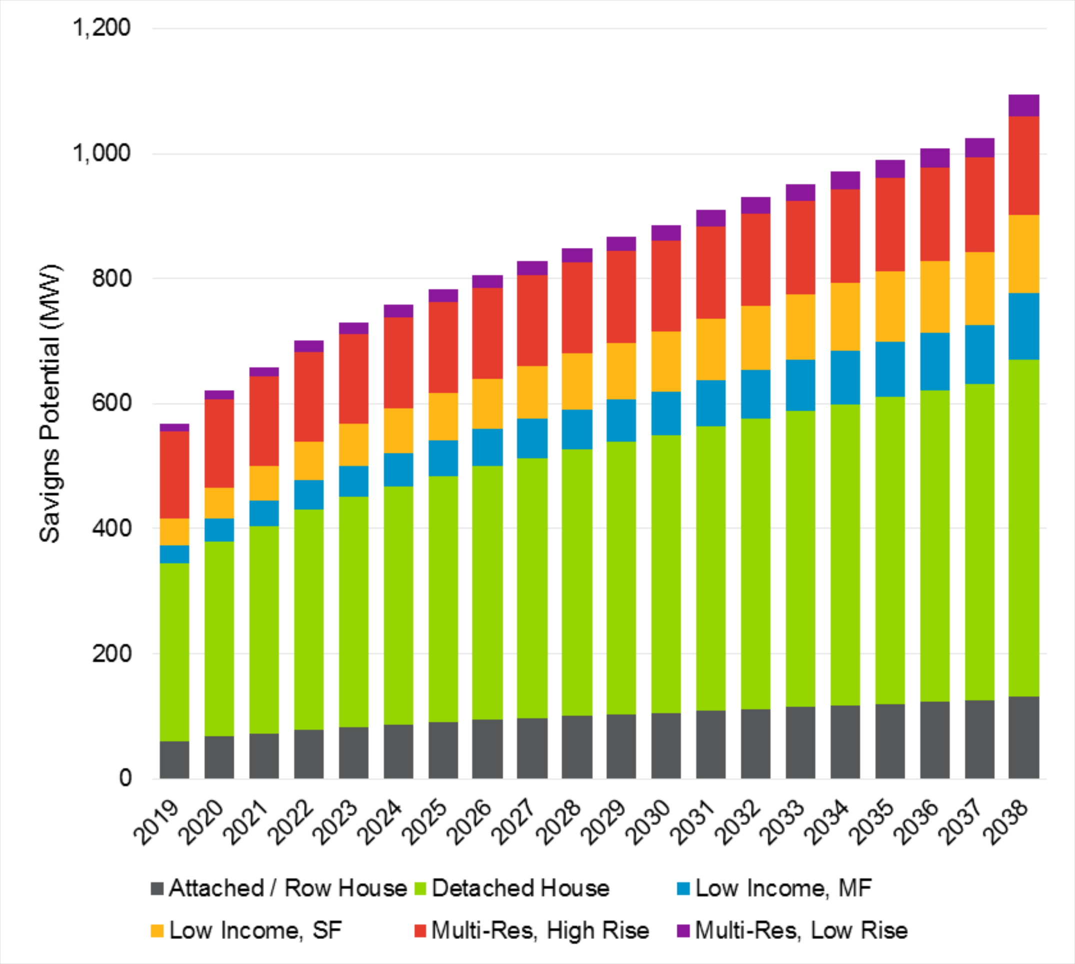
Figure E-1. Residential Electric Energy Economic Potential by Customer Segment (GWh)



Source: Navigant analysis

Figure E-2 shows the electric demand technical potential across all residential customer segments.

Figure E-2. Residential Electric Demand Technical Potential by Customer Segment (MW)

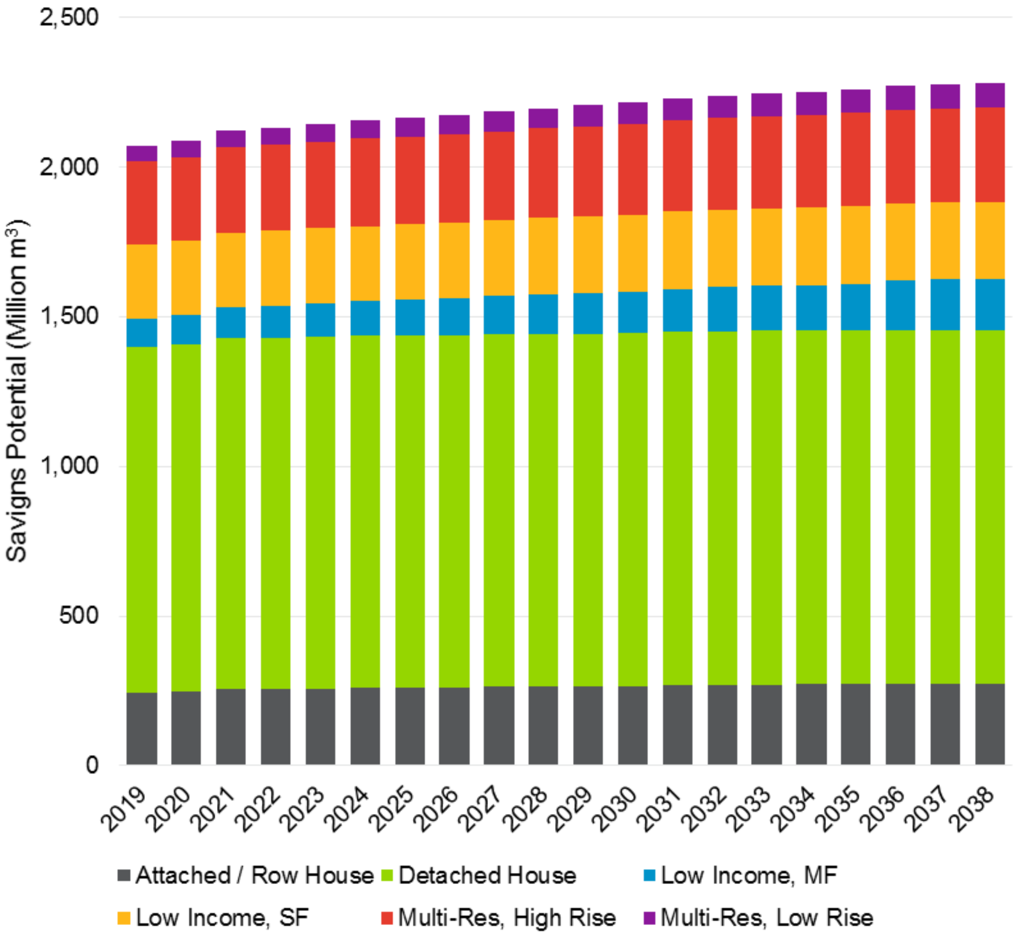


Source: Navigant analysis

When comparing the electric demand potential to the electric energy potential, there is almost no noticeable difference with respect to the spread of potential across customer segments.

Figure E-3 shows the natural gas energy economic potential across all residential customer segments. The general trend of each customer segment's potential follows that seen in technical potential with the main difference being reduced potential spread across each customer segment.

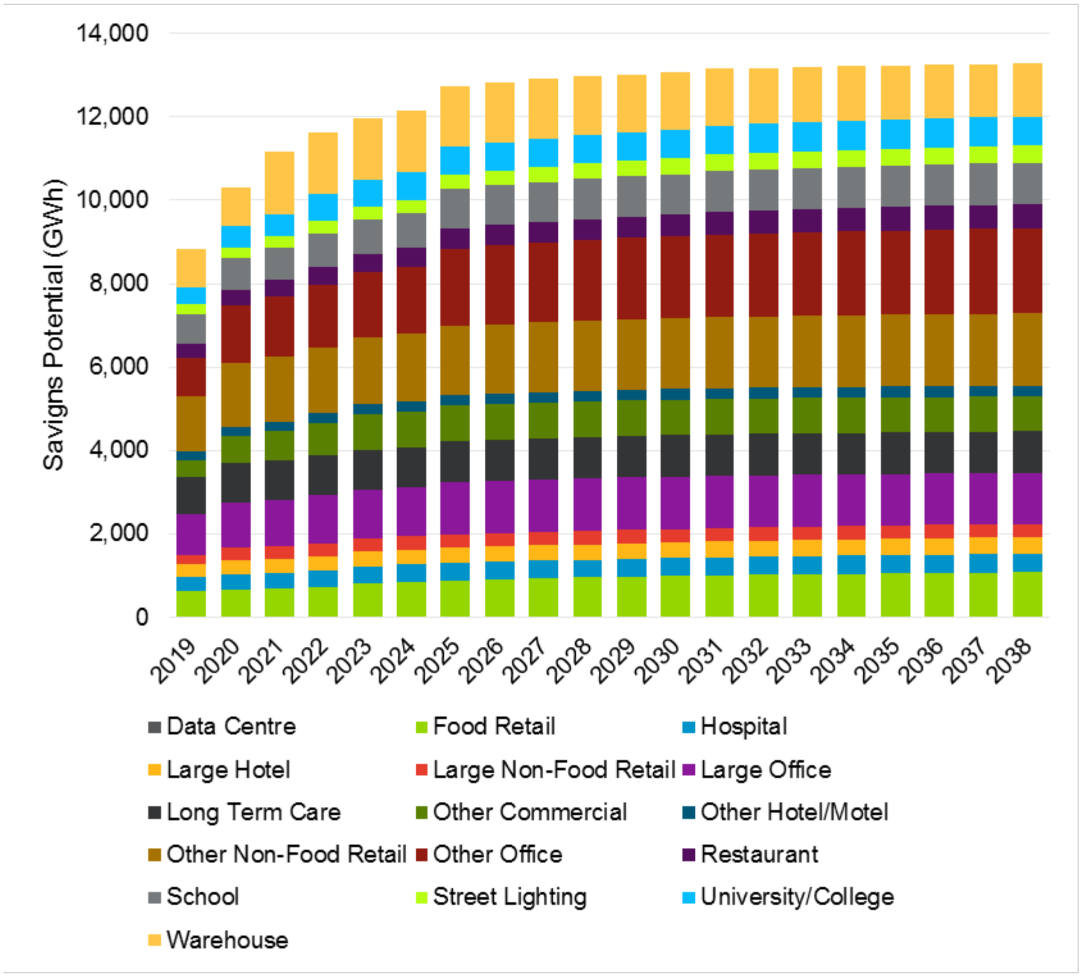
Figure E-3. Residential Natural Gas Energy Economic Potential by Customer Segment (Million m^3)



Source: Navigant analysis

Figure E-4 shows the electric energy economic potential across all commercial customer segments. The general trend of each customer segment's potential follows that seen in technical potential with the main difference seen with respect to more measures not being cost-effective in the first few years but slowly ramping up to match the growth rate seen in technical potential by 2024.

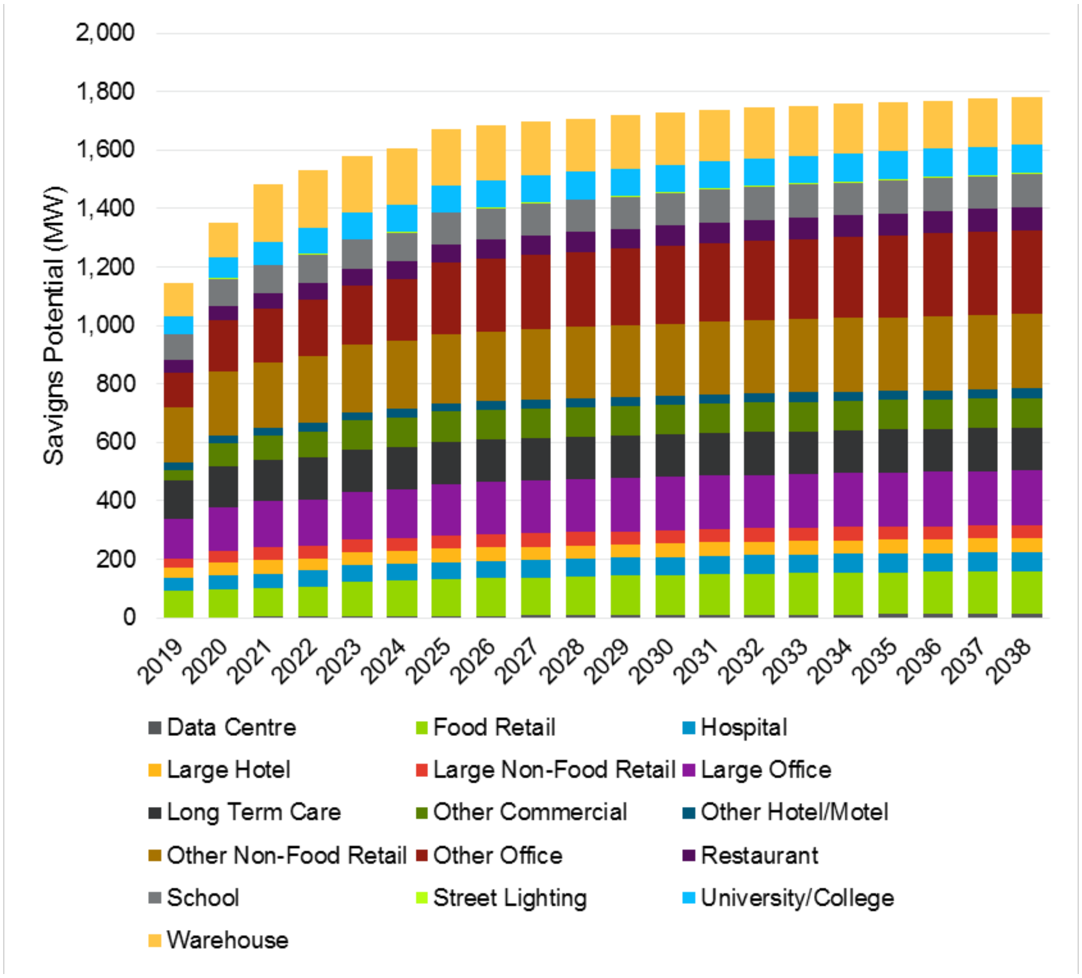
Figure E-4. Commercial Electric Energy Economic Potential by Customer Segment (GWh)



Source: Navigant analysis

Figure E-5 shows the electric demand technical potential across all commercial customer segments.

Figure E-5. Commercial Electric Demand Technical Potential by Customer Segment (MW)

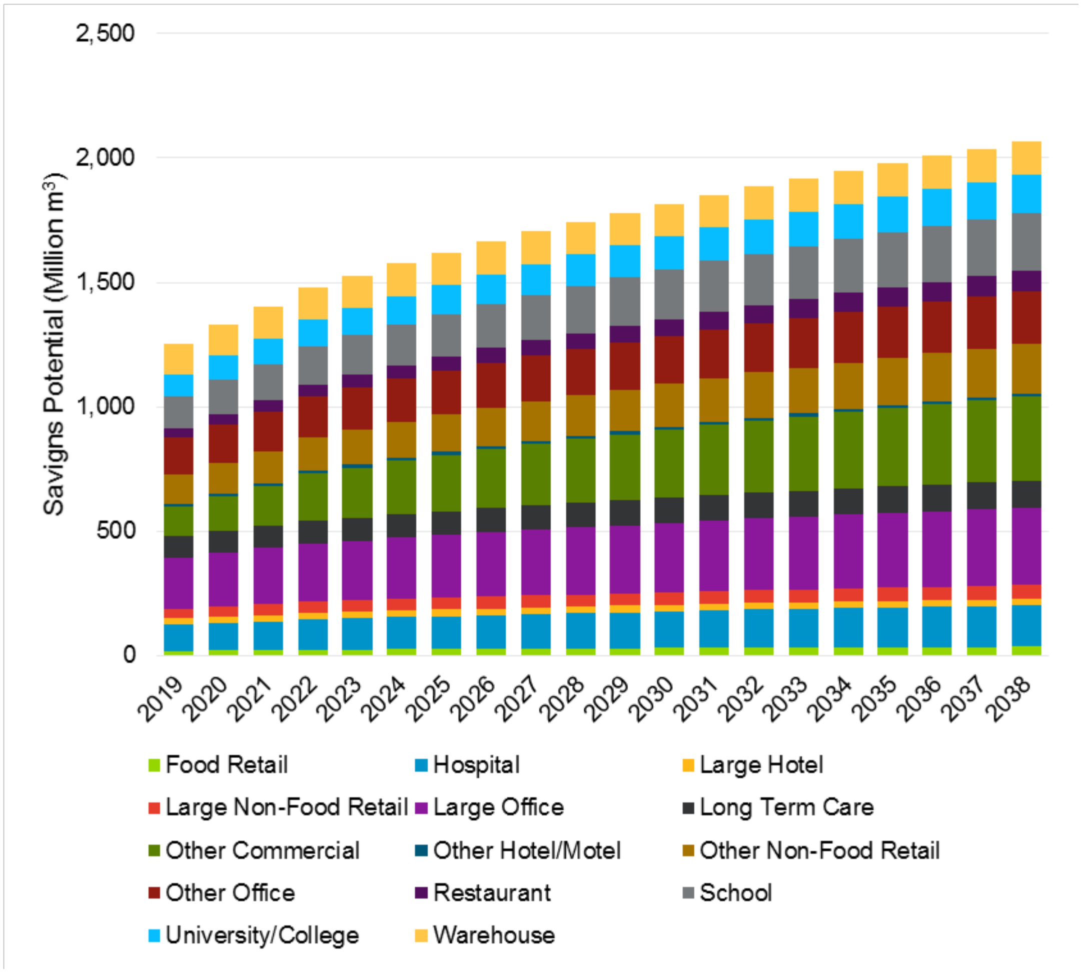


Source: Navigant analysis

When comparing the electric demand potential to the electric energy potential, there is almost no noticeable difference with respect to the spread of potential across customer segments.

Figure E-6 shows the natural gas energy economic potential across all commercial customer segments. The general trend of each customer segment's potential follows that seen in technical potential.

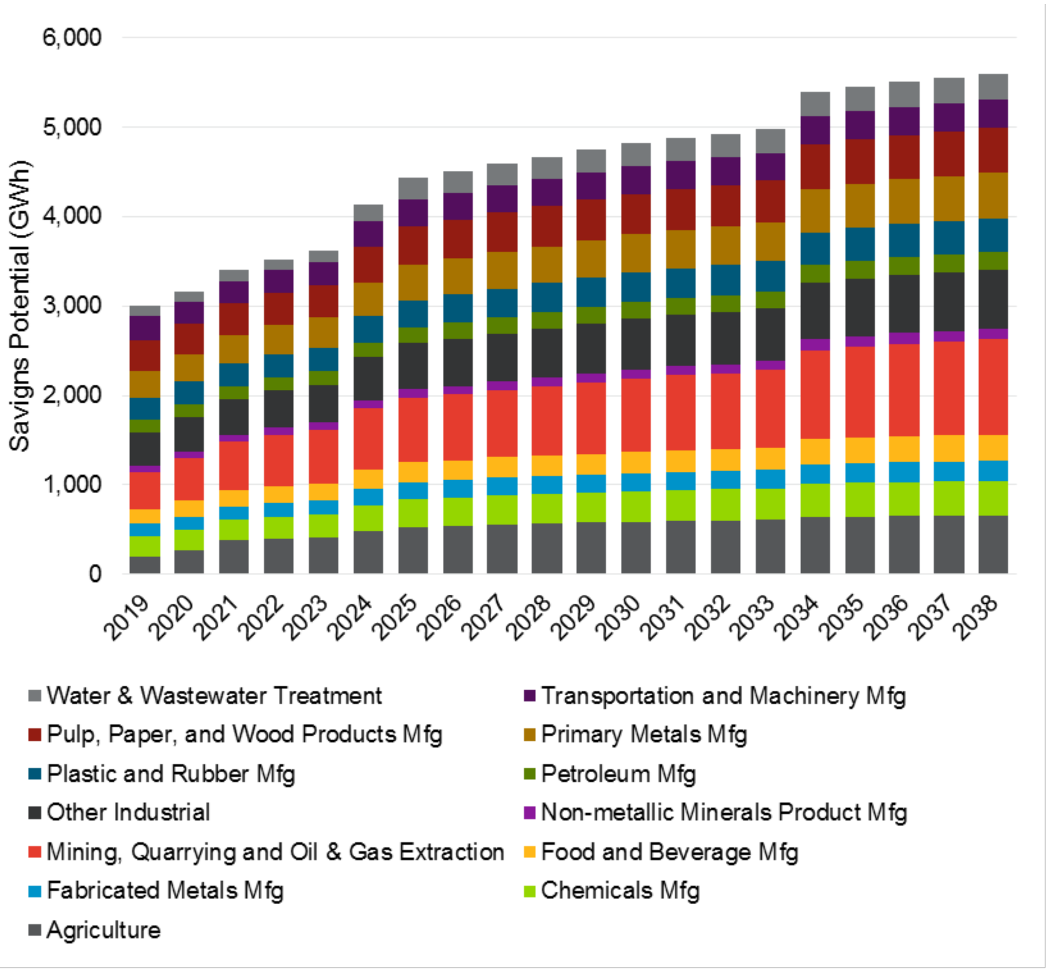
Figure E-6. Commercial Natural Gas Energy Economic Potential by Customer Segment (Million m^3)



Source: Navigant analysis

Figure E-7 shows the electric energy economic potential across all industrial customer segments. The general trend of each customer segment's potential follows that seen in technical potential with the main difference seen with respect to a few small stepwise jumps in 2024 and 2034. This was the result of a few measures becoming cost-effective in 2024 and 2034.

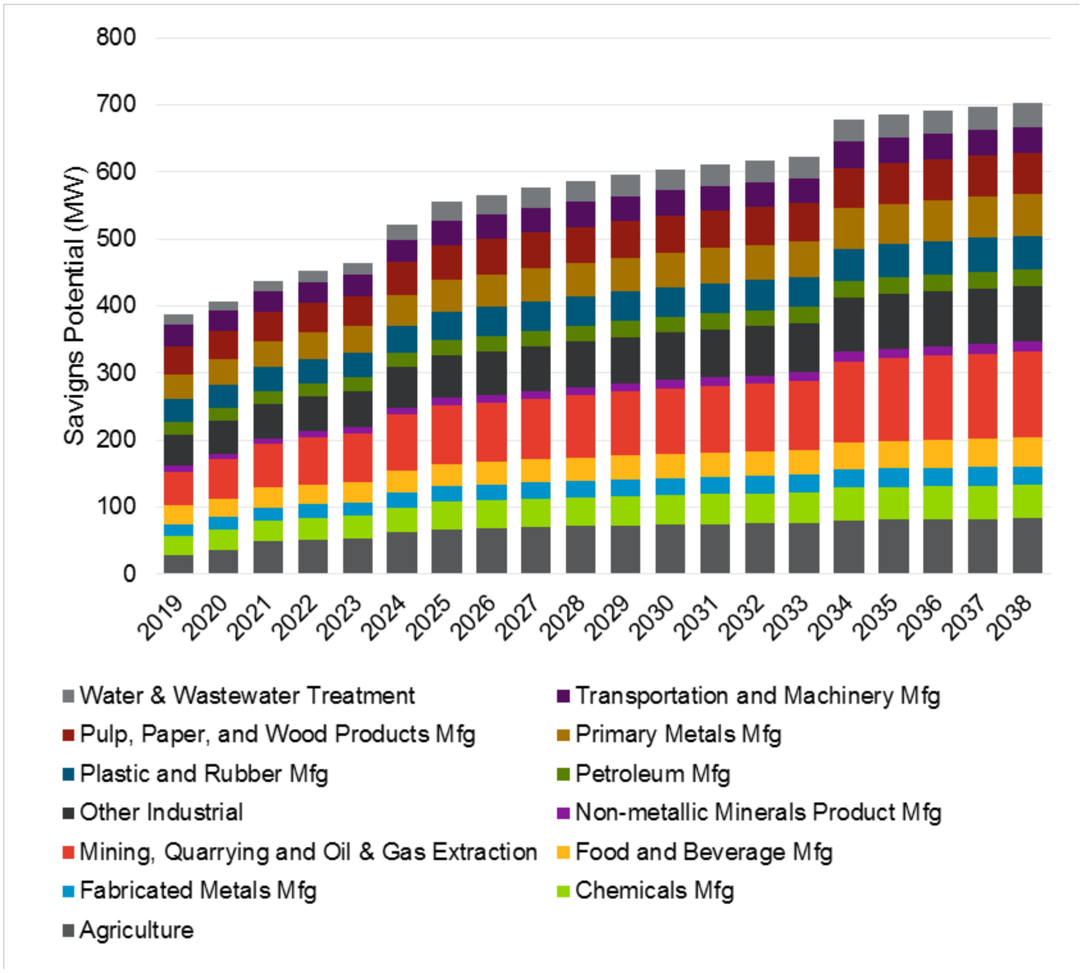
Figure E-7. Industrial Electric Energy Economic Potential by Customer Segment (GWh)



Source: Navigant analysis

Figure E-8 shows the electric demand technical potential across all industrial customer segments.

Figure E-8. Industrial Electric Demand Technical Potential by Customer Segment (MW)

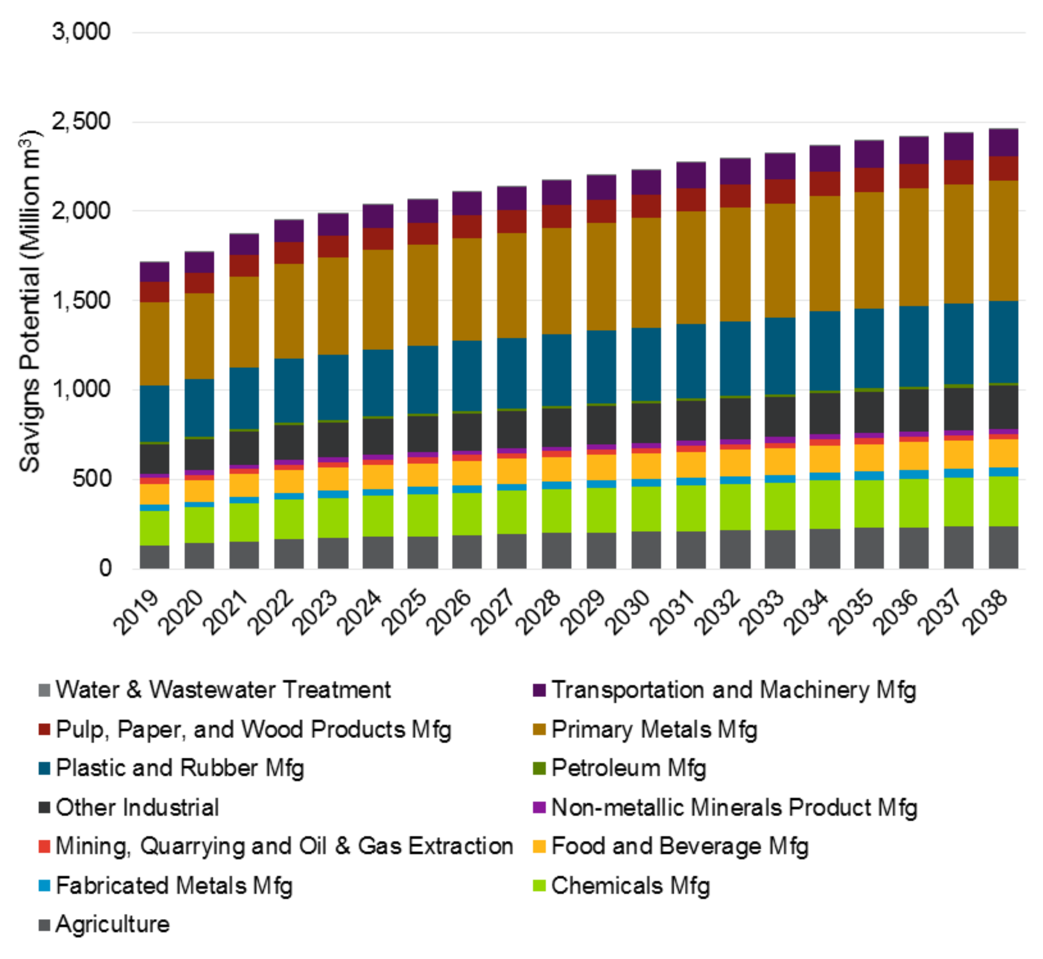


Source: Navigant analysis

When comparing the electric demand potential to the electric energy potential, there is almost no noticeable difference with respect to the spread of potential across customer segments.

Figure E-9 shows the natural gas energy economic potential across all industrial customer segments. The general trend of each customer segment's potential is nearly identical to that seen in technical potential.

Figure E-9. Industrial Natural Gas Energy Economic Potential by Customer Segment (Million m^3)

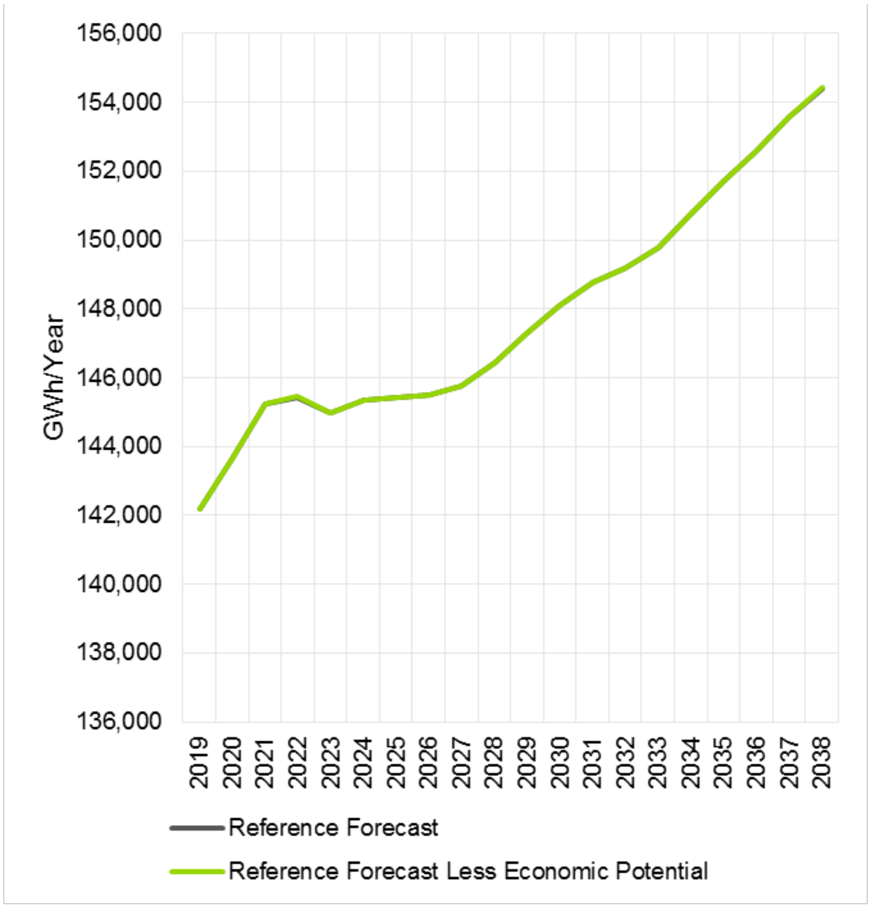


Source: Navigant analysis

E.1.2 Fuel Switching Potential

Figure E-10 contrasts the estimated economic electrification potential across the potential reference forecast period with the total forecast consumption over the same period. As shown, there is almost zero economic fuel switching potential as the lines are completely overlapping.

Figure E-10. Electric Energy Reference Forecast and Economic Electrification Potential



Source: Navigant analysis

No fuel switching measures in the residential sector were cost-effective so no results will be displayed for that sector. Only one measure, the heat pump water heater, was cost-effective and it was only cost-effective in the smallest customer segment in the smallest service territory, other commercial in Bruce. This amounts to 0.006% of the technical potential being cost-effective and was only possible given the unusually high water heating energy intensity exhibited by the other commercial customer segment in the Bruce zone.

Navigant believes even this small amount of fuel switching potential was only possible due to the compounding effects of the very small amount of forecast consumption and building stock[104] in this zone, combined with the imprecision associated with the forecast for this particular combination of end use, customer segment, and zone and doesn't believe given the current forecasts of electric and natural gas

---

[104] In 2038, the Bruce zone is forecast to account for less than 0.06% of commercial floor space in Ontario, 0.06% of provincial commercial electricity consumption, and approximately 0.02% of provincial commercial natural gas consumption.

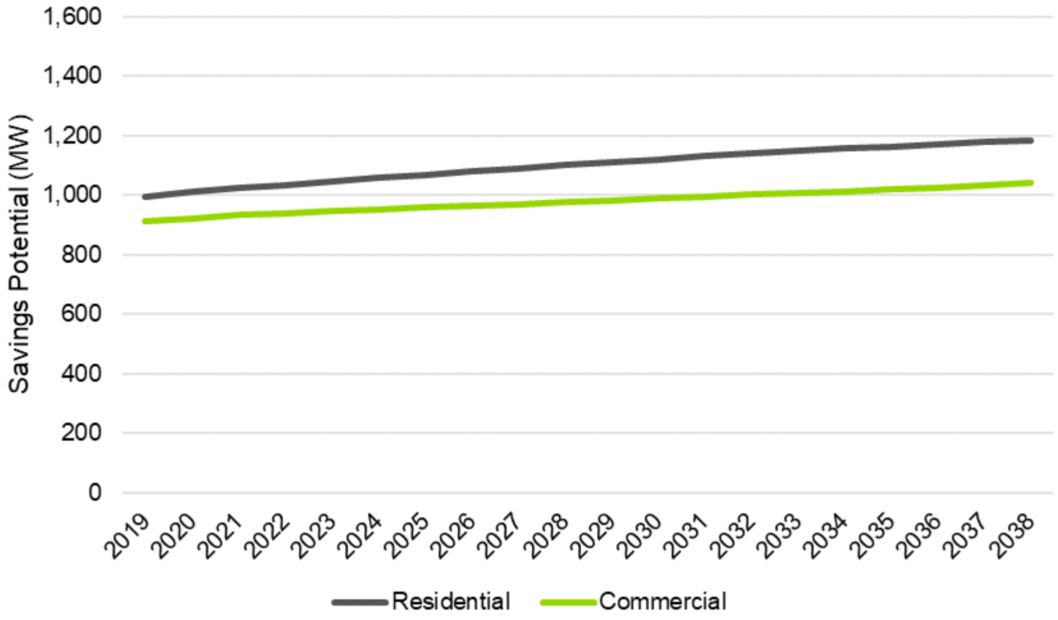
avoided costs in Ontario paired with the cost of fuel switching measures that any of the measures should be cost-effective.

Given that there is only economic potential for one measure and how small that potential is, detailed economic potential results will not be provided.

E.1.3 Technically Feasible Demand Response

Figure E-11 shows the estimated technically feasible electric demand response[105] potential associated with measures adopted in the economic potential, across the potential reference forecast period for each sector. When comparing to the technical potential, all of the residential energy efficiency measures suitable for demand response are economic, while the growth in commercial DR potential is much flatter compared to the technically feasible DR potential associated with the technical potential. This is due to the central lighting control system not being cost-effective.

Figure E-11. Electric Demand Response Economic Potential by Sector (MW)



Source: Navigant analysis

E.1.4 Technical and Economic Potential by Sector and Fuel Type

The following tables (Table E-1, Table E-2, Table E-3, Table E-4, Table E-5, and Table E-6) detail the technical and economic potential of all measures, and compares the economic potential to the technical potential. This is done with respect to the residential, commercial, and industrial sectors and for the electric and natural gas fuel types, respectively. Note that the savings shown below are net of cross-fuel interactive effects. This may result in some cases in negative savings, where a measure designed

---

[105] Note that this estimate of DR potential does not account for the incremental costs associated with implementing the necessary controls required to convert the energy efficiency measures (e.g., switches, software, other control infrastructure) and so must be understood to be the technical potential of DR associated with the economically feasible DR-capable energy efficiency measures.

primarily to save one fuel increases the consumption of another fuel (e.g., the heat recovery ventilator that delivers significant natural gas savings, but does so at the cost of increased electricity consumption).

Table E-1. Residential Electricity – Technical and Economic Potential in 2038

Measure #	Measure Name	Technical Potential (GWh)	Economic Potential (GWh)	Economic Potential as a % of Technical Potential (%)
1	ENERGY STAR A Line, PAR, MR Lamps	2,130	2,130	100%
2	ENERGY STAR LED Bulbs General Purpose LEDs	2,099	2,099	100%
3	ENERGY STAR LED Specialty Bulbs	1,918	1,918	100%
4	Networked/ Connected - Indoor LED Lamp	1,315	0	0%
5	Smart Power Bar	1,202	1,202	100%
6	ENERGY STAR Refrigerator	1,005	0	0%
7	Smart Burners	914	285	31%
8	ENERGY STAR Ground Source Heat Pump	808	0	0%
9	Ductless Mini-Split Heat Pump	804	804	100%
10	ENERGY STAR Clothes Washer	801	801	100%
11	Adaptive Thermostat	700	700	100%
12	Heat Pump Clothes Dryer	683	0	0%
13	Induction Cooking Stove Top	563	0	0%
14	ENERGY STAR Air Source Heat Pump	458	458	100%
15	ENERGY STAR Central Air Conditioner	436	0	0%
16	Air Sealing	432	432	100%
17	ENERGY STAR Light Fixture	401	140	35%
18	ENERGY STAR Clothes Dryer	390	261	67%
19	Car Block Heater Timer	371	371	100%
20	Ductless Mini-Split Air Conditioner	369	0	0%
21	ENERGY STAR Torchiere	326	326	100%
22	Variable Speed Pool Pump Motor	317	317	100%
23	Passive Attic Ventilation	256	0	0%
24	Building Recommissioning, Operations and Maintenance (O&M) Improvements	246	246	100%
25	ENERGY STAR Windows	234	0	0%
26	Basement Wall Insulation	227	227	100%
27	Basement or Crawlspace Insulation	188	0	0%
28	Attic Insulation	175	175	100%
29	Lighting Motion Sensors, Timers, Dimmers	174	0	0%
30	Solar Powered Attic Fan	150	0	0%
31	ENERGY STAR Room Air Conditioner	143	142	100%
32	Wall Insulation	137	6	4%
33	Comprehensive Draft Proofing	125	125	100%
34	Variable Refrigerant Flow Heat Pump	119	0	0%
35	Air Source Heat Pump	117	0	0%
36	Home Energy Reports	109	62	57%
37	Networked/ Connected - Indoor LED Luminaire	108	0	0%
38	ENERGY STAR Ceiling Fan/Lighting	100	0	0%

Measure #	Measure Name	Technical Potential (GWh)	Economic Potential (GWh)	Economic Potential as a % of Technical Potential (%)
39	Furnace with ECM	94	0	0%
40	ENERGY STAR Freezer	90	61	68%
41	LED Downlight	90	4	5%
42	Radiant Barrier	88	0	0%
43	LED Parking Lot Fixture	81	81	100%
44	Heavy Duty Outdoor/Holiday Plug-in Timers	80	72	90%
45	Heat Pump Water Heater	75	0	0%
46	Ceiling Insulation	69	0	0%
47	Tankless Water Heater	67	39	58%
48	Window Film	67	0	0%
49	Refrigerator Recycling	64	64	100%
50	Clothes Drying Racks	59	59	100%
51	Heat Recovery Ventilator	57	55	97%
52	Freezer Recycling	57	57	100%
53	Duct Insulation	56	55	98%
54	Occupancy Sensors MF	53	53	100%
55	Floor Insulation	46	46	100%
56	Central Lighting Control System	45	0	0%
57	Dehumidifier Recycling	39	0	0%
58	LED Exterior Area Lights - LED Fixture (200W)	38	38	100%
59	Solar Water Heating System	37	0	0%
60	Advanced BAS/Controllers	36	36	100%
61	LED Tube Re-Lamp	34	34	100%
62	High Efficiency Storage Water Heater	33	0	0%
63	Minimise Hot and Warm Clothes Wash	31	31	100%
64	Outside Air Economizer	31	31	100%
65	Furnace Whistle	31	31	100%
66	ENERGY STAR Dishwasher	31	0	0%
67	INTEGRAL LED TROFFERS	29	0	0%
68	Early Hot Water Heater Replacement	28	0	0%
69	Duct Insulation MF	25	24	98%
70	ENERGY STAR Dehumidifier	23	23	100%
71	Central Air Conditioner Maintenance	23	0	0%
72	Condensing Make Up Air Unit	21	21	100%
73	High Efficiency Chiller (avg of water and air cooled)	21	21	100%
74	CO Sensors for parking garage exhaust fans	20	20	100%
75	Drain Water Heat Recovery	19	0	0%
76	Demand Control Ventilation	17	17	100%
77	ENERGY STAR LED LAMPS (REFLECTOR LAMPs/MR16/PAR 16)	15	15	100%
78	Variable Frequency Drive (VFD)	13	13	100%
79	Water Heater Temperature Setback	10	10	100%
80	DHW Recirculation Systems	9	0	0%

Measure #	Measure Name	Technical Potential (GWh)	Economic Potential (GWh)	Economic Potential as a % of Technical Potential (%)
81	Air Source Heat Pump Maintenance	8	0	0%
82	VFD on Pumps	4	4	100%
83	ENERGY STAR LED Lamps (General Service Lamps)	4	4	100%
84	HVAC Optimisation	3	0	0%
85	ECM MOTORS FOR HVAC APPLICATION (FAN-POWERED VAV BOX)	3	3	100%
86	Beverage Vending Machine Controls	2	2	100%
87	Chilled Water Optimisation	1	1	100%
88	Wall Insulation MF	0	0	8%
89	LED Recessed Downlights	0	0	0%
90	LED High Bay Fixture	0	0	100%
91	Solar Water Preheat (Pools/DHW)	0	0	0%
92	Photocell Controls (Outdoor)	0	0	0%

Source: Navigant analysis

Table E-2. Commercial Electricity – Technical and Economic Potential in 2038

Measure #	Measure Name	Technical Potential (GWh)	Economic Potential (GWh)	Economic Potential as a % of Technical Potential (%)
1	Central Lighting Control System	2,155	0	0%
2	Building Recommissioning, Operations and Maintenance (O&M) Improvements	1,732	1,732	100%
3	ENERGY STAR LED LAMPS (REFLECTOR LAMPs/MR16/PAR 16)	1,066	959	90%
4	LED Low/High Bay	1,062	1,062	100%
5	LED Troffer/Surface/Suspended	865	865	100%
6	LED Replacement Lamp (Tube)	830	830	100%
7	High Efficiency Air Source Heat Pump	780	780	100%
8	LLLC - High Impact Application	741	397	54%
9	LLLC - Low Impact Application	734	249	34%
10	Smart Strip Plug Outlets	673	0	0%
11	Networked/Connected - High Impact Application	670	58	9%
12	LED EXTERIOR AREA LIGHTS - LED fixture (200W)	669	669	100%
13	Education and Capacity Building/Energy Behavior	652	651	100%
14	LED parking lot fixture	634	634	100%
15	Networked/Connected - Low Impact Application	630	27	4%
16	Variable Refrigerant Flow Heat Pump	541	1	0%
17	Refrigerated Display Case Doors	513	408	80%
18	Furnace Tune-Up	476	476	100%
19	LED street light fixture	409	409	100%
20	Reach-in Shaded Pole to ECM/PSC Evaporator Fan Motor	388	388	100%
21	Demand Control Ventilation	347	340	98%

Measure #	Measure Name	Technical Potential (GWh)	Economic Potential (GWh)	Economic Potential as a % of Technical Potential (%)
22	Advanced BAS/Controllers	340	340	100%
23	Data Centre Storage/Server Virtualisation	311	311	100%
24	Strip Curtains	258	258	100%
25	Unitary Air-Conditioning Unit	232	231	100%
26	Centrally controlled desktop PC/NETWORK PC POWER MANAGEMENT SOFTWARE	213	213	100%
27	Door Gasket Freezer/Refrigerator	205	53	26%
28	Refrigeration Optimisation	184	0	0%
29	LED or Equivalent Sign Lighting	183	183	100%
30	Variable Frequency Drive (VFD)	158	158	100%
31	Condensing Make Up Air Unit	155	19	12%
32	Adaptive Thermostats	154	154	100%
33	VFD on Pumps	148	148	100%
34	ENERGY STAR FREEZER	138	0	0%
35	Super-High Efficiency Furnaces (Emerging Tech)	137	0	0%
36	ENERGY STAR ICE MACHINES - Ice Making Head	126	0	0%
37	ENERGY STAR LED LAMPS (General Service Lamps)	126	125	99%
38	Demand Control Kitchen Ventilation	121	114	94%
39	Air Handler with Dedicated Outdoor Air Systems	120	120	100%
40	Indoor Daylight Sensors/Photocell Dimming Control	105	2	2%
41	Refrigerated Display Case LED	101	80	79%
42	Adding reflective (White) roof treatment or a green roof	92	0	0%
43	Occupancy Sensors	80	80	100%
44	Ground Source Heat Pump	79	0	0%
45	ECM MOTORS FOR EVAPORATOR FANS for refrigeration (WALK-IN)	75	75	100%
46	Condensing Unit Heaters or other Efficient Unit Heating System	72	72	100%
47	HOTEL OCCUPANCY CONTROLS (HVAC + LIGHTING)	69	0	0%
48	ENERGY STAR Refrigerator	69	0	0%
49	High R-Value Glass Doors/no-heat glass door	66	0	0%
50	Freezer Case Light Sensor	62	62	100%
51	Evaporator Fan Controls	60	60	100%
52	Chilled Water Optimisation	58	58	100%
53	Elec Storage WH 2.30 Et	51	51	100%
54	ENERGY STAR Griddle (74% eff)	51	51	100%
55	BEVERAGE VENDING MACHINE CONTROLS	43	43	100%
56	Water Source Heat Pump (4 ton)	42	42	100%
57	Refrigeration Commissioning	41	0	0%
58	CO Sensors for parking garage exhaust fans	31	31	100%
59	Anti-sweat heat (ASH) controls - Cooler/Freezer	26	0	0%
60	Temperature Adjustment in Commercial Freezers	23	23	100%

Measure #	Measure Name	Technical Potential (GWh)	Economic Potential (GWh)	Economic Potential as a % of Technical Potential (%)
61	Energy Efficient Laboratory Fume Hood	20	20	100%
62	ENERGY STAR Fryer (84% eff)	18	18	100%
63	Outside Air Economizer	18	18	100%
64	Vertical Night Covers	18	18	100%
65	Duct Insulation, R8	16	16	100%
66	Water Heating (DHW) Pipe Insulation (Add 3/4\ Foam)"	15	15	100%
67	Roof Insulation/Ceiling Insulation (R25 Code to R35)	15	0	0%
68	High Efficiency Small Instantaneous Water Heater	14	10	67%
69	ENERGY STAR Dishwasher	13	13	100%
70	LED RECESSED DOWNLIGHTS	11	1	8%
71	Suction Pipe Insulation Freezer/Refrigerator	10	10	100%
72	ENERGY STAR Steam Cookers	9	9	100%
73	Evaporator Coil Defrost (Cooler)	8	0	0%
74	SYNCHRONOUS BELT	7	0	0%
75	Ozone Laundry Treatment	7	7	100%
76	Solar Water Preheat (Pools/DHW)	4	4	100%
77	Efficient compressor motor	4	2	57%
78	Heat Pump Water Heater (50 Gallons)	4	0	0%
79	Notched V belts for HVAC Systems	3	3	76%
80	Demand controlled Circulating Systems	3	3	100%
81	Room AC (w/ louvered sides) 14 SEER from 12 SEER code	3	0	6%
82	Thermostat Setback	3	3	100%
83	ECM MOTORS FOR HVAC APPLICATION (FAN-POWERED VAV BOX)	3	3	99%
84	Commercial Hot Food Holding Cabinets	3	1	30%
85	PTAC (12 EER/10,000 BTU)	2	2	98%
86	Energy Recovery Ventilation and Ventilation (Enhanced)	2	1	32%
87	Wall Insulation	2	0	11%
88	Solar Preheat Make up Air	2	0	0%
89	CEE Tier 2/ENERGY STAR Clothes Washers	2	2	100%
90	Ductless Mini-Split Heat Pumps	2	2	100%
91	Solar Electric Water Heater (50 Gallon)	2	0	0%
92	Auto Off Time Switch or Time Clock control	1	1	100%
93	HVAC Optimisation	1	1	57%
94	Low Flow Pre-Rinse Spray Nozzle	1	1	100%
95	High Efficiency Chiller (avg of water and air cooled)	1	0	11%
96	eCube	0	0	0%
97	EC Plug Fan for Data Centre (under cabinet)	0	0	50%
98	Air Curtains	0	0	100%
99	VSD Air Compressor	0	0	100%
100	Exterior Photocell	0	0	0%

Measure #	Measure Name	Technical Potential (GWh)	Economic Potential (GWh)	Economic Potential as a % of Technical Potential (%)
101	High Efficiency Induction Cooking	0	0	0%
102	Electric Convection Combination Ovens	0	0	100%
103	Heat Recovery Ventilator	-43	-2	6%

Source: Navigant analysis

Table E-3. Industrial Electricity – Technical and Economic Potential in 2038

Measure #	Measure Name	Technical Potential (GWh)	Economic Potential (GWh)	Economic Potential as a % of Technical Potential (%)
1	Pump System Optimisation	941	911	97%
2	HE Lighting	728	728	100%
3	Air Leak Survey and Repair	612	612	100%
4	Air Compressor Optimisation	504	504	100%
5	Efficient Compressed Air Nozzles	487	487	100%
6	Recommissioning	424	424	100%
7	SEM	424	424	100%
8	Pump Equipment Upgrade	413	413	100%
9	High Efficiency HVAC Fans	262	262	100%
10	Premium Efficient Motors	180	0	0%
11	Greenhouse Grow Lights	174	174	100%
12	Process Optimisation (Elec)	171	171	100%
13	Material Handling Improvements	78	78	100%
14	HE HVAC Controls	77	0	0%
15	Fan System Optimisation	69	69	100%
16	Pulp and Paper Process Improvements	65	65	100%
17	Refiner Plate Improvements	60	60	100%
18	HE HVAC Units	55	0	0%
19	Ventilation Optimisation	38	18	48%
20	Process Heat Recovery	37	37	100%
21	High Efficiency Battery Charger	25	25	100%
22	Cold Storage Retrofit	24	0	0%
23	VAV Conversion Project	23	23	100%
24	Synchronous Belts	21	0	0%
25	Improved Controls - Process Cooling	20	20	100%
26	HVLS Fans	20	0	0%
27	Efficient Irrigation	20	20	100%
28	Process Improvements	17	17	100%
29	Refrigeration Compressor VFD	14	14	100%
30	Efficient Transformer	12	0	0%
31	Chiller Optimisation	11	0	0%
32	Improved Controls - Process Heating	11	11	100%
33	High Efficiency Welders	10	0	0%
34	Cooling Tower Optimisation	9	9	100%

Measure #	Measure Name	Technical Potential (GWh)	Economic Potential (GWh)	Economic Potential as a % of Technical Potential (%)
35	Low Energy Livestock Waterers	7	0	0%
36	Engine Block Heater Timer	7	7	100%
37	Dairy Pre-Cooler	5	5	100%
38	Free Cooling	5	5	100%
39	Air Compressor Heat Recovery	3	3	100%
40	Optimise Compressed Air Dryer	2	0	0%
41	Heat Lamps/Heat Pad	1	0	8%
42	Efficient Refrigeration Compressor	1	1	100%
43	Creep Heat Controller	1	0	0%
44	Dual and Natural Exhaust Ventilation Systems	0	0	0%
45	Dairy Water Heater	0	0	48%

Source: Navigant analysis

Table E-4. Residential Natural Gas – Technical and Economic Potential in 2038

Measure #	Measure Name	Technical Potential (million_m3)	Economic Potential (million_m3)	Economic Potential as a % of Technical Potential (%)
1	Air Sealing	505	505	100%
2	Adaptive Thermostat	498	498	100%
3	Condensing Storage Water Heater	259	0	0%
4	Tankless Water Heater	218	0	0%
5	ENERGY STAR Windows	192	0	0%
6	Condensing Boiler	168	115	68%
7	Heat Recovery Ventilator	161	161	100%
8	Comprehensive Draft Proofing	152	152	100%
9	High Efficiency Storage Water Heater	145	0	0%
10	High Efficiency Condensing Furnace	144	134	92%
11	High Efficiency Fireplace with Pilotless Ignition	143	143	100%
12	Wall Insulation	140	12	9%
13	Attic Insulation	123	123	100%
14	DHW Recirculation Systems	117	0	0%
15	Basement or Crawlspace Insulation	105	0	0%
16	Basement Wall Insulation	103	103	100%
17	Condensing Make Up Air Unit	99	99	100%
18	Window Film	72	0	0%
19	Furnace Tune Up	70	0	0%
20	Solar Water Heating System	64	0	0%
21	Advanced BAS/Controllers	63	63	100%
22	Ceiling Insulation	52	0	0%
23	Building Recommissioning, Operations and Maintenance (O&M) Improvements	52	52	100%
24	Duct Insulation MF	41	37	91%
25	Floor Insulation	40	40	100%

Measure #	Measure Name	Technical Potential (million_m3)	Economic Potential (million_m3)	Economic Potential as a % of Technical Potential (%)
26	Duct Insulation	38	38	99%
27	Home Energy Reports	34	20	60%
28	Demand Control Ventilation	28	28	100%
29	Early Hot Water Heater Replacement	23	0	0%
30	Drain Water Heat Recovery	20	0	0%
31	Pool Cover	13	13	100%
32	High Efficiency Gas Pool Heater	12	0	0%
33	Wall Insulation MF	6	6	100%
34	Water Heater Temperature Setback	6	6	100%
35	ENERGY STAR Clothes Dryer	3	0	0%
36	ENERGY STAR Clothes Washer	1	0	30%
37	Clothes Drying Racks	1	1	100%
38	Minimise Hot and Warm Clothes Wash	1	1	100%
39	Solar Water Preheat (Pools/DHW)	0	0	0%
40	LED High Bay Fixture	0	0	100%
41	LED Recessed Downlights	0	0	0%
42	ENERGY STAR LED Lamps (General Service Lamps)	0	0	100%
43	ENERGY STAR LED LAMPS (REFLECTOR LAMPs/MR16/PAR 16)	0	0	100%
44	INTEGRAL LED TROFFERS	-1	0	0%
45	LED Tube Re-Lamp	-1	-1	100%
46	LED Exterior Area Lights - LED Fixture (200W)	-1	-1	100%
47	Central Lighting Control System	-1	0	0%
48	Occupancy Sensors MF	-1	-1	100%
49	LED Downlight	-2	0	5%
50	Networked/ Connected - Indoor LED Luminaire	-3	0	0%
51	Lighting Motion Sensors, Timers, Dimmers	-4	0	0%
52	ENERGY STAR Light Fixture	-7	-2	29%
53	ENERGY STAR Torchiere	-8	-8	100%
54	Networked/ Connected - Indoor LED Lamp	-40	0	0%
55	ENERGY STAR LED Specialty Bulbs	-63	-63	100%
56	ENERGY STAR A Line, PAR, MR Lamps	-63	-63	100%
57	ENERGY STAR LED Bulbs General Purpose LEDs	-67	-67	100%

Source: Navigant analysis

Table E-5. Commercial Natural Gas – Technical and Economic Potential in 2038

Measure #	Measure Name	Technical Potential (million_m3)	Economic Potential (million_m3)	Economic Potential as a % of Technical Potential (%)
1	Condensing Boiler | Std	359	359	100%
2	Gas Fired Rooftop Units	242	242	100%
3	Demand Control Ventilation	225	216	96%

Measure #	Measure Name	Technical Potential (million_m3)	Economic Potential (million_m3)	Economic Potential as a % of Technical Potential (%)
4	Building Recommissioning, Operations and Maintenance (O&M) Improvements	200	200	100%
5	Boilers - Advanced Controls (Steam Systems)	152	152	100%
6	Adaptive Thermostats	135	135	100%
7	Condensing Make Up Air Unit	123	123	100%
8	Gas Fired Heat Pump	102	101	99%
9	Advanced BAS/Controllers	78	78	100%
10	Demand Control Kitchen Ventilation	76	76	100%
11	Air Handler with Dedicated Outdoor Air Systems	75	75	100%
12	Condensing Unit Heaters or other Efficient Unit Heating System	72	72	100%
13	Energy Recovery Ventilation and Ventilation (Enhanced)	69	5	7%
14	Education and Capacity Building/Energy Behavior	64	63	99%
15	Steam System Optimisation	40	40	100%
16	Destratification	38	38	100%
17	Furnace Tune-Up	38	38	100%
18	Super-High Efficiency Furnaces (Emerging Tech)	31	0	0%
19	Heat Recovery Ventilator	29	2	8%
20	High Efficiency Condensing Furnace AFUE 95% from 80% code	28	0	0%
21	Wall Insulation	21	21	100%
22	Boiler Measures	18	0	0%
23	Energy Efficient Laboratory Fume Hood	15	15	100%
24	Demand controlled Circulating Systems	11	11	100%
25	Infrared Heaters	11	11	100%
26	ENERGY STAR Fryer (84% eff)	10	10	100%
27	Roof Insulation/Ceiling Insulation (R25 Code to R35)	9	0	0%
28	Condensing Storage Water Heater	9	0	0%
29	High Efficiency Underfired Broilers	9	9	100%
30	Duct Insulation, R8	9	9	100%
31	Ozone Laundry Treatment	8	8	100%
32	ENERGY STAR Griddle (74% eff)	7	7	100%
33	Refrigerated Display Case Doors	6	5	80%
34	Condensing Tankless Water Heater	5	0	0%
35	Gas Heat Pump Water Heater	5	0	10%
36	ENERGY STAR Dishwasher	4	4	100%
37	HOTEL OCCUPANCY CONTROLS (HVAC + LIGHTING)	4	0	0%
38	Dock Door Seals	3	0	0%
39	Ice Rink Heat Recovery	3	0	0%
40	CEE Tier 2/ENERGY STAR Clothes Washers	1	1	100%
41	Drain Water Heat Recovery (DWHR) | Retro	1	1	100%
42	Refrigeration Waste Heat Recover	1	1	98%

Measure #	Measure Name	Technical Potential (million_m3)	Economic Potential (million_m3)	Economic Potential as a % of Technical Potential (%)
43	ENERGY STAR Steam Cooker	1	1	100%
44	Drain Water Heat Recovery (DWHR) |New	1	1	100%
45	Low Flow Pre-Rinse Spray Nozzle	1	1	100%
46	Solar Water Preheat (Pools/DHW)	0	0	96%
47	Gas Convection Oven	0	0	0%
48	Air Curtains	0	0	100%
49	Solar Preheat Make up Air	0	0	0%
50	Super High Perf Glazing |RET	0	0	0%
51	Super High Perf Glazing |New	0	0	0%
52	Auto Off Time Switch or Time Clock control	0	0	100%
53	LED RECESSED DOWNLIGHTS	0	0	4%
54	Freezer Case Light Sensor	-1	-1	100%
55	Occupancy Sensors	-3	-3	100%
56	Indoor Daylight Sensors/Photocell Dimming Control	-3	0	1%
57	ENERGY STAR LED LAMPS (General Service Lamps)	-4	-4	98%
58	Refrigerated Display Case LED	-4	-3	80%
59	Adding reflective (White) roof treatment or a green roof	-12	0	0%
60	Networked/Connected - Low Impact Application	-15	-1	4%
61	Networked/Connected - High Impact Application	-16	-1	9%
62	LLLC - Low Impact Application	-17	-6	34%
63	LLLC - High Impact Application	-17	-9	54%
64	LED Replacement Lamp (Tube)	-19	-19	100%
65	LED Troffer/Surface/Suspended	-20	-20	100%
66	LED Low/High Bay	-25	-25	100%
67	ENERGY STAR LED LAMPS (REFLECTOR LAMPs/MR16/PAR 16)	-27	-23	86%
68	Anti-sweat heat (ASH) controls - Cooler/Freezer	-36	0	0%

Source: Navigant analysis

Table E-6. Industrial Natural Gas – Technical and Economic Potential in 2038

Measure #	Measure Name	Technical Potential (million_m3)	Economic Potential (million_m3)	Economic Potential as a % of Technical Potential (%)
1	Process Heat Improvements	905	905	100%
2	Boiler Upgrade	350	350	100%
3	Process Heat Recovery (Gas)	303	303	100%
4	Recommissioning	218	218	100%
5	High Efficiency Burners	171	171	100%
6	Improved Controls -Process Heating Gas	139	139	100%
7	Greenhouse Envelope Improvements	95	95	100%
8	Boiler Tune Up	43	0	0%
9	High Efficiency HVAC Fans (Gas)	43	43	100%

Measure #	Measure Name	Technical Potential (million_m3)	Economic Potential (million_m3)	Economic Potential as a % of Technical Potential (%)
10	Insulation - Steam	42	42	100%
11	VAV Conversion Project (Gas)	35	35	100%
12	Direct Contact Water Heaters	31	31	100%
13	Steam Leak Repairs	26	0	0%
14	HE HVAC Controls	24	24	100%
15	Loading Dock Seals	24	0	0%
16	Steam Trap Repair	20	20	100%
17	High Efficiency Furnaces	20	13	65%
18	Insulation - Steam (AG)	18	18	100%
19	Air Compressor Heat Recovery	15	15	100%
20	Steam Turbine Optimisation	10	10	100%
21	HE Stock Tank	9	9	100%
22	Process Optimisation (Gas)	9	9	100%
23	Gas Turbine Optimisation	7	7	100%
24	Ventilation Optimisation (Gas)	5	5	100%
25	Solar Walls	5	5	100%
26	HE HVAC Units	2	1	67%
27	Boiler Tune Up - Direct	1	0	0%
28	Process Heat Recovery (Gas) - HVAC	1	1	100%
29	Insulation - Steam - Direct	1	1	100%
30	Insulation - Steam - HVAC	0	0	100%
31	Boiler Tune Up - HVAC	0	0	0%

Source: Navigant analysis

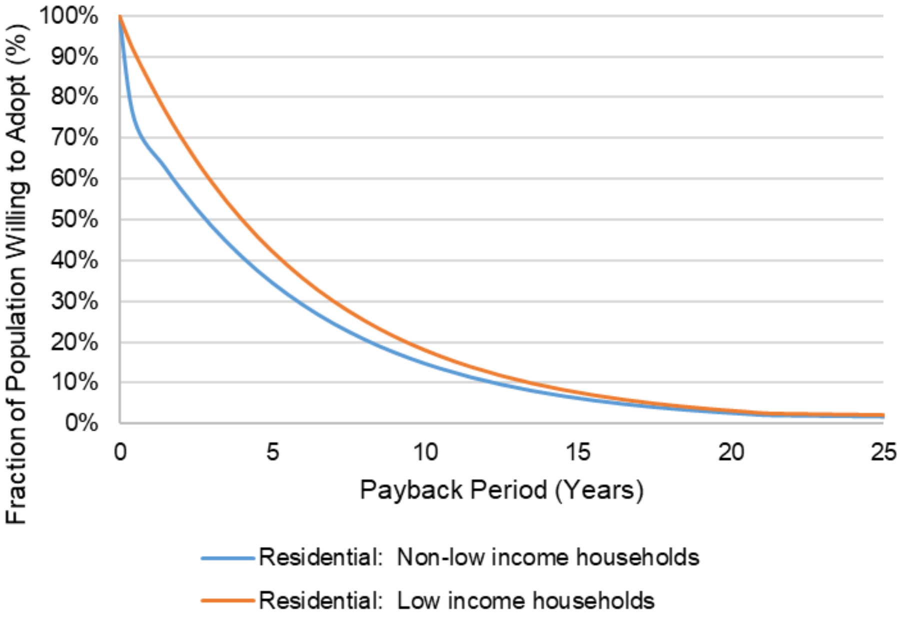
Appendix F. ACHIEVABLE POTENTIAL FORECAST

F.1 Detailed Methodology

Navigant used the Delphi Panel survey responses and virtual discussion feedback to estimate a set of exponential equations to deliver the set of payback acceptance curves used in the achievable potential analysis. The output payback acceptance curves are presented below.

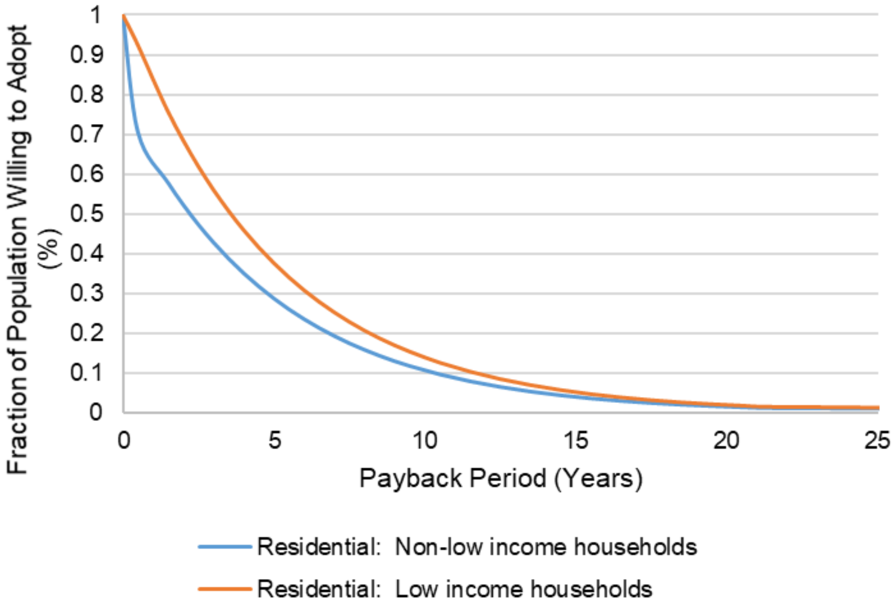
Note that the residential sector is the only one where the curves pertaining to the low cost and high cost measures were materially different enough to use separate curves.

Figure F-1. Residential Low-Cost Payback Acceptance Curves



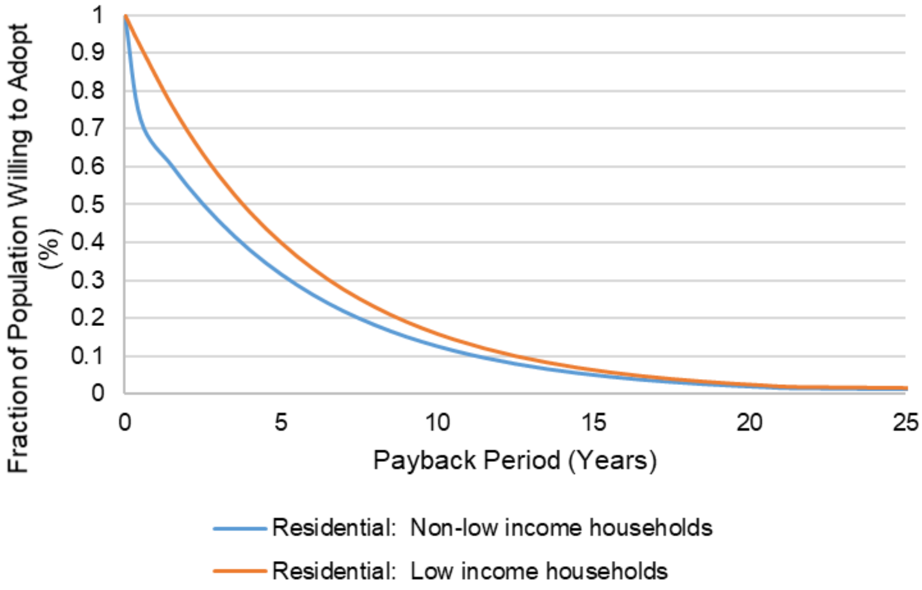
Source: Navigant analysis

Figure F-2. Residential High-Cost Payback Acceptance Curves



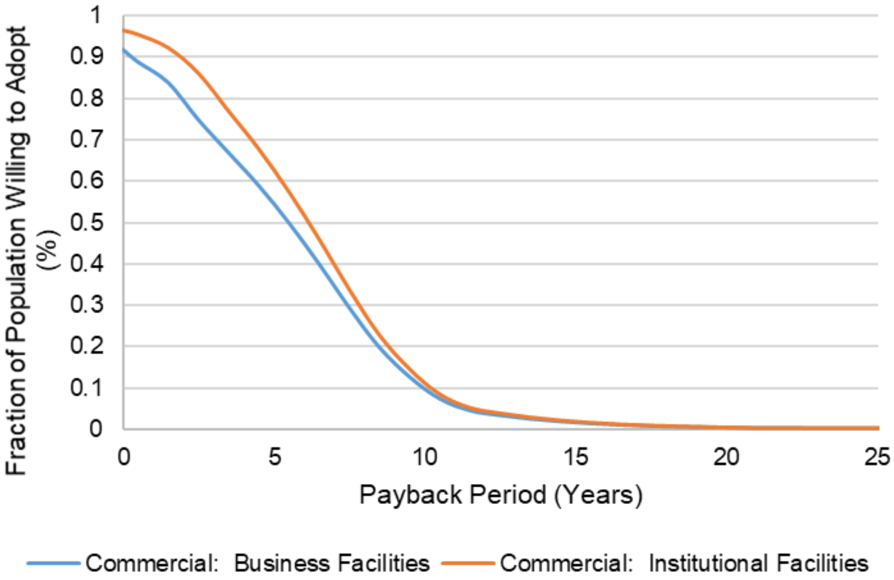
Source: Navigant analysis

Figure F-3. Residential Average Payback Acceptance Curve



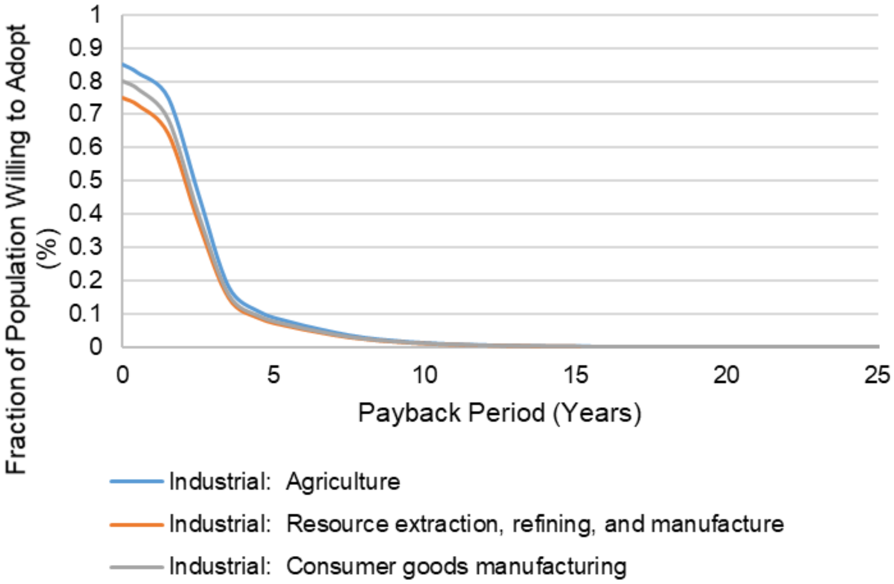
Source: Navigant analysis

Figure F-4. Commercial Average Payback Acceptance Curves



Source: Navigant analysis

Figure F-5. Industrial Average Payback Acceptance Curves



Source: Navigant analysis

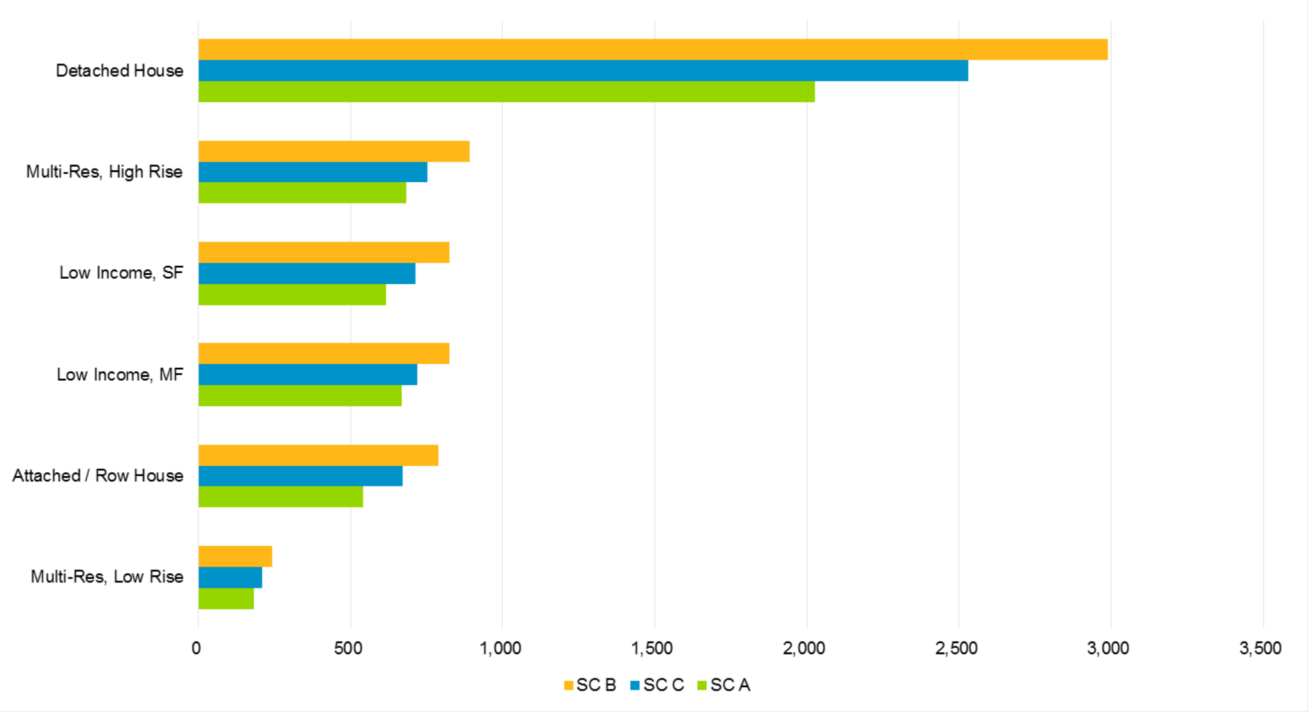
F.2 Results (Expanded)

F.2.1 Achievable Potential Results by Sector and Segment

Residential Sector

Figure F-6 shows the total electric energy achievable savings potential for each customer segment and scenario in 2038. As would be expected, the detached house customer segment is projected to achieve the greatest absolute savings potential. This segment accounts for nearly half of all forecast residential consumption in 2038. One thing not evident from the graphic below is that while the detached house segment delivers the highest proportion of potential, the multifamily segments all deliver the most potential as a proportion of forecast consumption. This is due to opportunities offered by whole building measures (e.g., building recommissioning) that deliver high savings at a relatively low incremental cost.

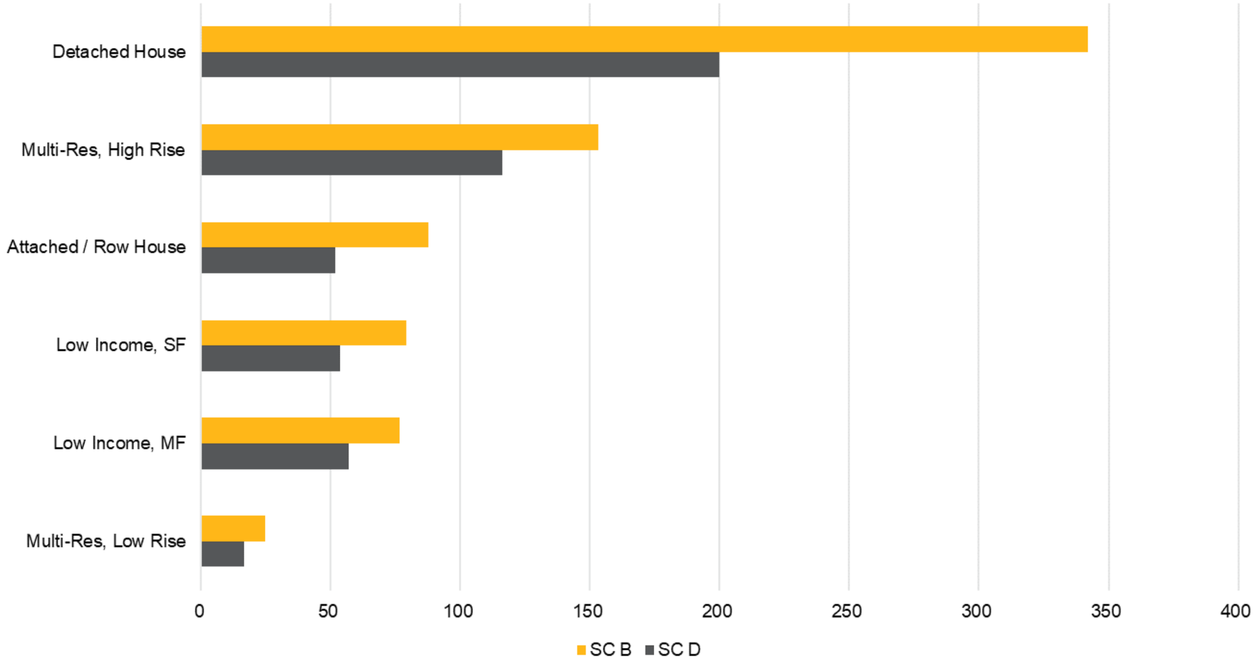
Figure F-6. Electric Energy Achievable Savings Potential by Customer Segment and Scenario in 2038 (GWh)



Source: Navigant analysis

Figure F-7 shows the total electric summer peak demand achievable savings potential for each customer segment for Scenarios B and D in 2038. Similar to the electric energy savings potential, the detached house is the greatest contributor to achievable potential in this sector, for the same reasons.

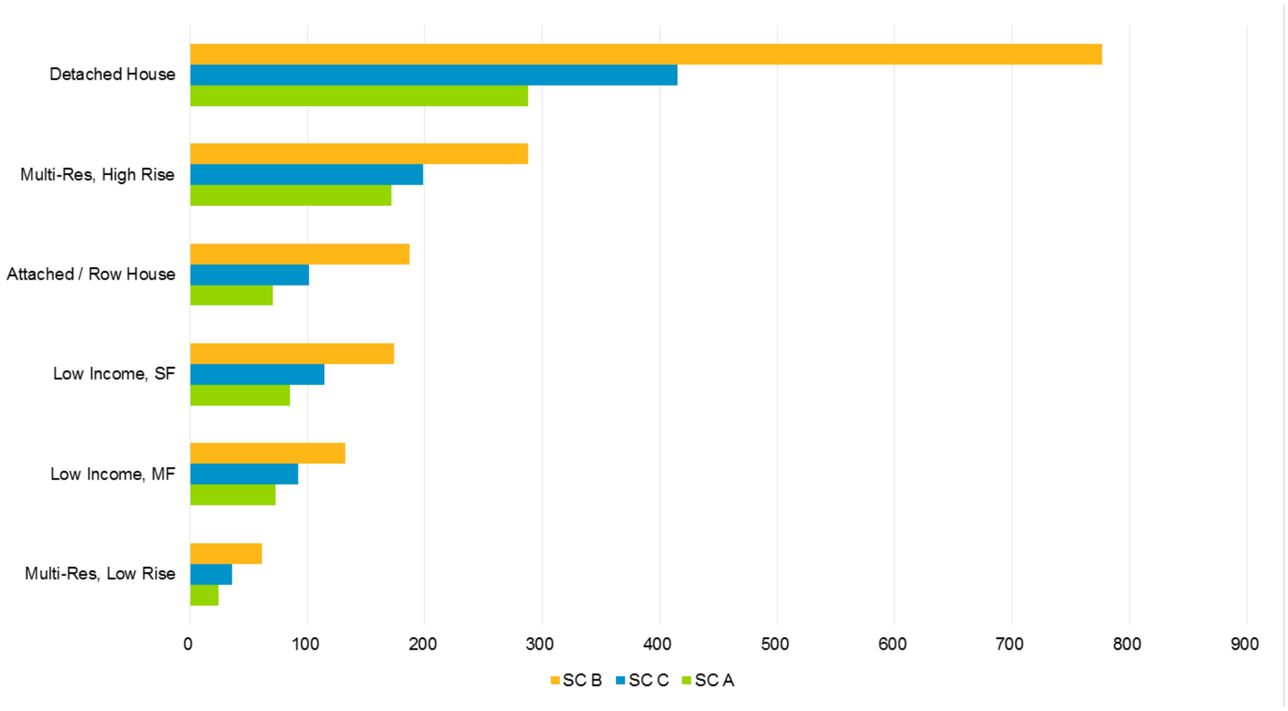
Figure F-7. Electric Summer Peak Demand Achievable Savings Potential by Customer Segment and Scenario in 2038 (MW)



Source: Navigant analysis

Figure F-8 shows the total natural gas energy achievable savings potential for each customer segment and scenario in 2038. Similar to the electric energy potential, although the multi-family segments offer the most potential as a percent of the reference forecast, the detached house customer segment delivers the greatest absolute savings potential simply due to the fact that this segment accounts for nearly 60% of the reference forecast natural gas consumption in the terminal year of the potential study.

Figure F-8. Natural Gas Energy Achievable Savings Potential by Customer Segment and Scenario in 2038 (Million m^3)

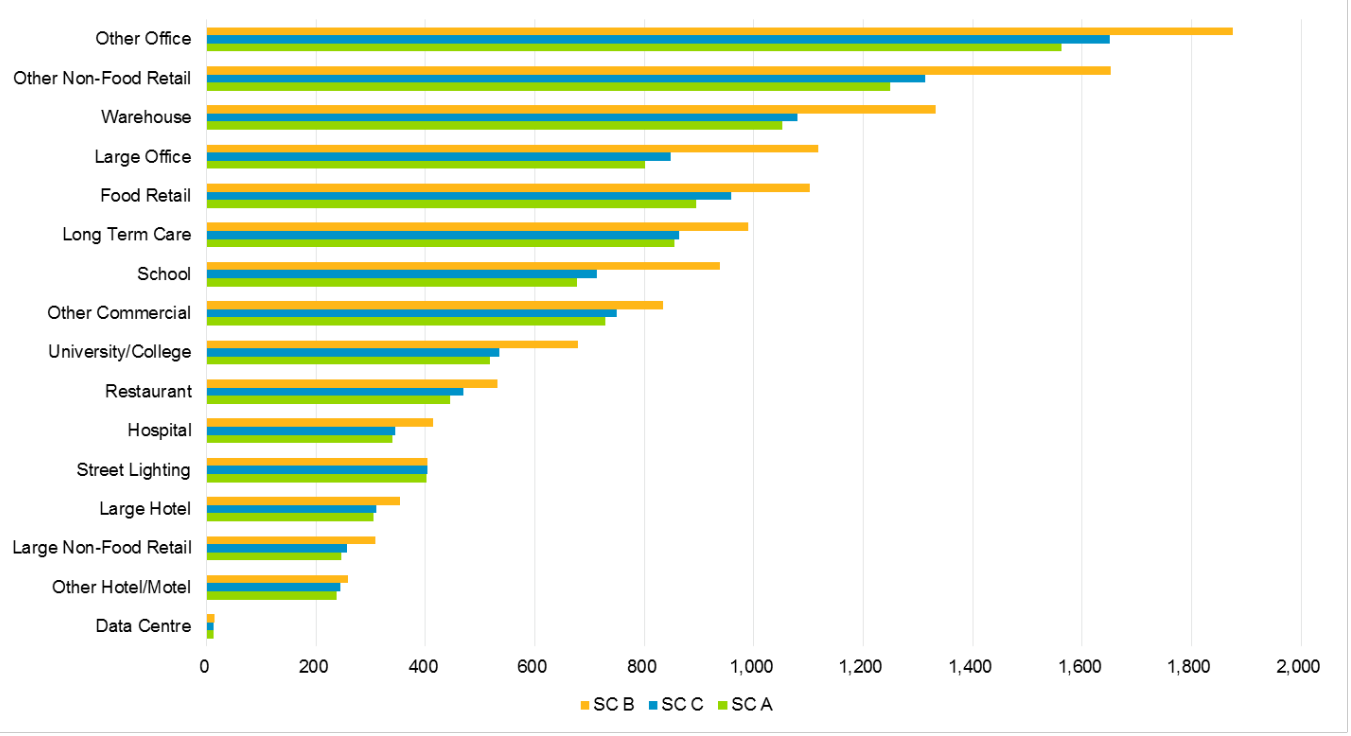


Source: Navigant analysis

Commercial Sector

Figure F-9 shows the total electric energy achievable savings potential for each customer segment and scenario in 2038. The other office customer segment shows the highest absolute potential, although the potential as a percentage of reference forecast (not shown) is highest for street lighting – unsurprising giving the very large proportion of potential that is attributable to the lighting end use. Overall, the contributions by segment to align quite closely with the overall contribution to sectoral consumption (see Chapter 3).

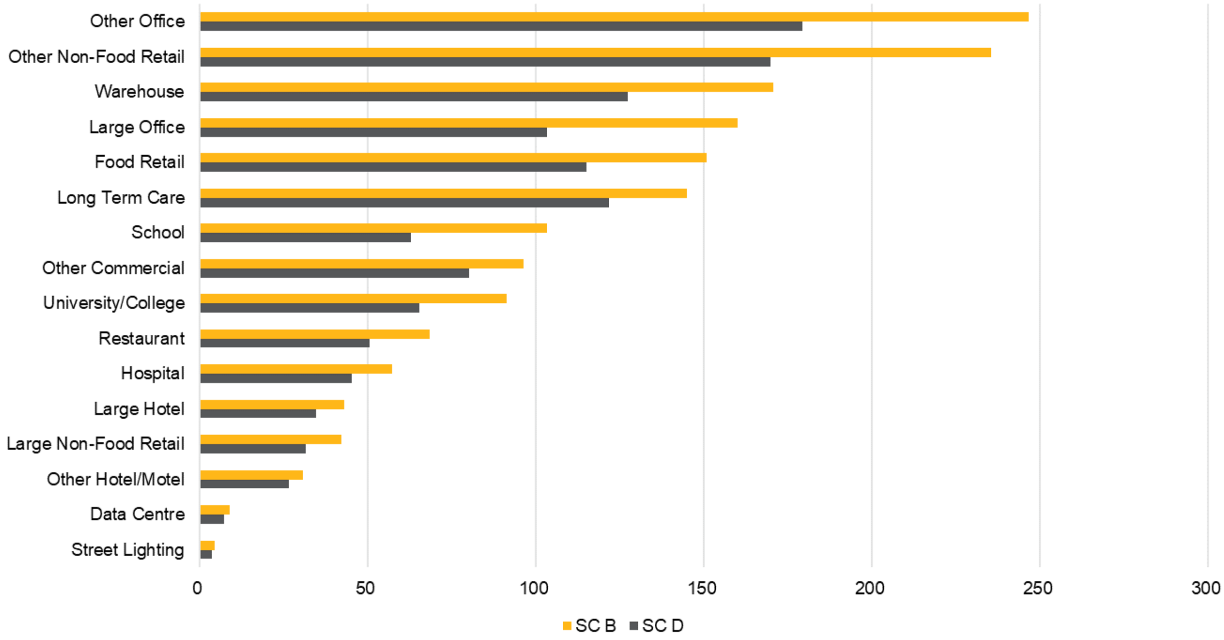
Figure F-9. Electric Energy Achievable Savings Potential by Customer Segment and Scenario in 2038 (GWh)



Source: Navigant analysis

Figure F-10 shows the total electric summer peak demand achievable savings potential for each customer segment for Scenarios B and D in 2038. Similar to the electric energy savings potential, the other office customer segment achieved the greatest demand savings potential.

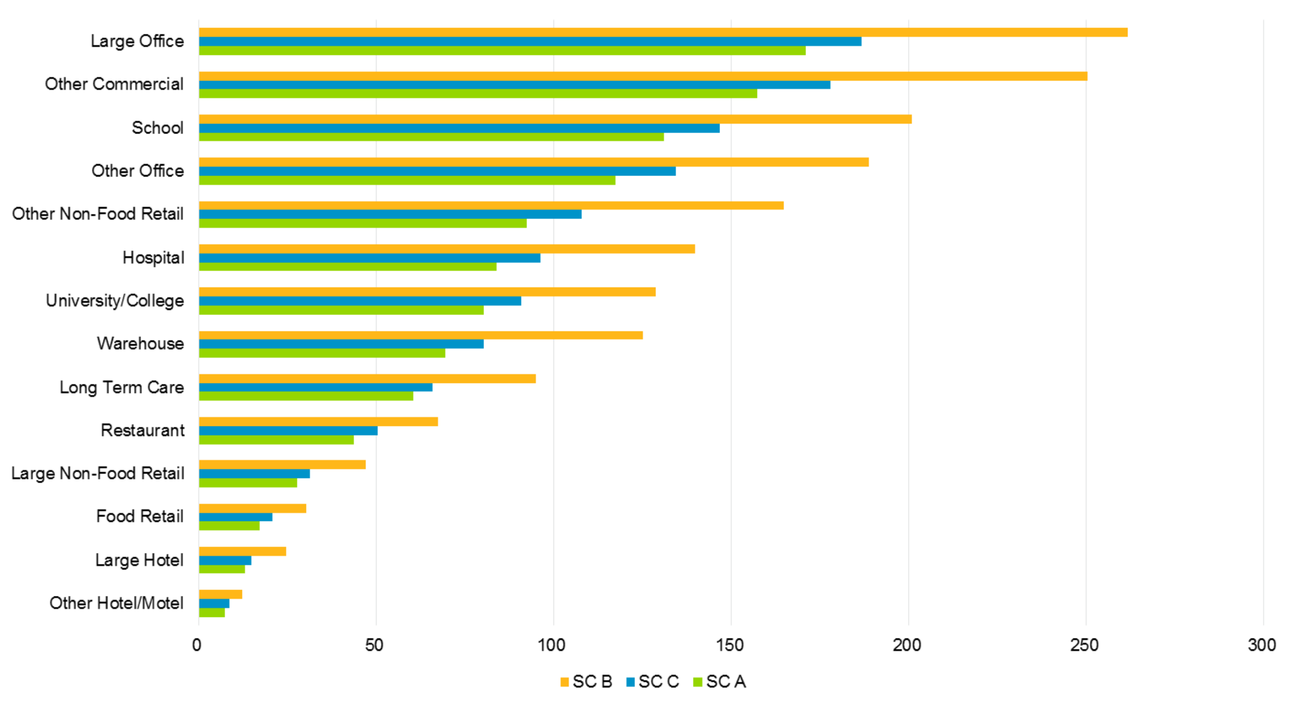
Figure F-10. Electric Summer Peak Demand Achievable Savings Potential by Customer Segment and Scenario in 2038 (MW)



Source: Navigant analysis

Figure F-11 shows the total natural gas energy achievable savings potential for each customer segment and scenario in 2038. Similar to the electric energy potential, the magnitude of each segment's contribution to potential is, for the most part, approximately proportional to each segment's contribution to commercial sector forecast consumption.

Figure F-11. Natural Gas Energy Achievable Savings Potential by Customer Segment and Scenario in 2038 (Million m^3)

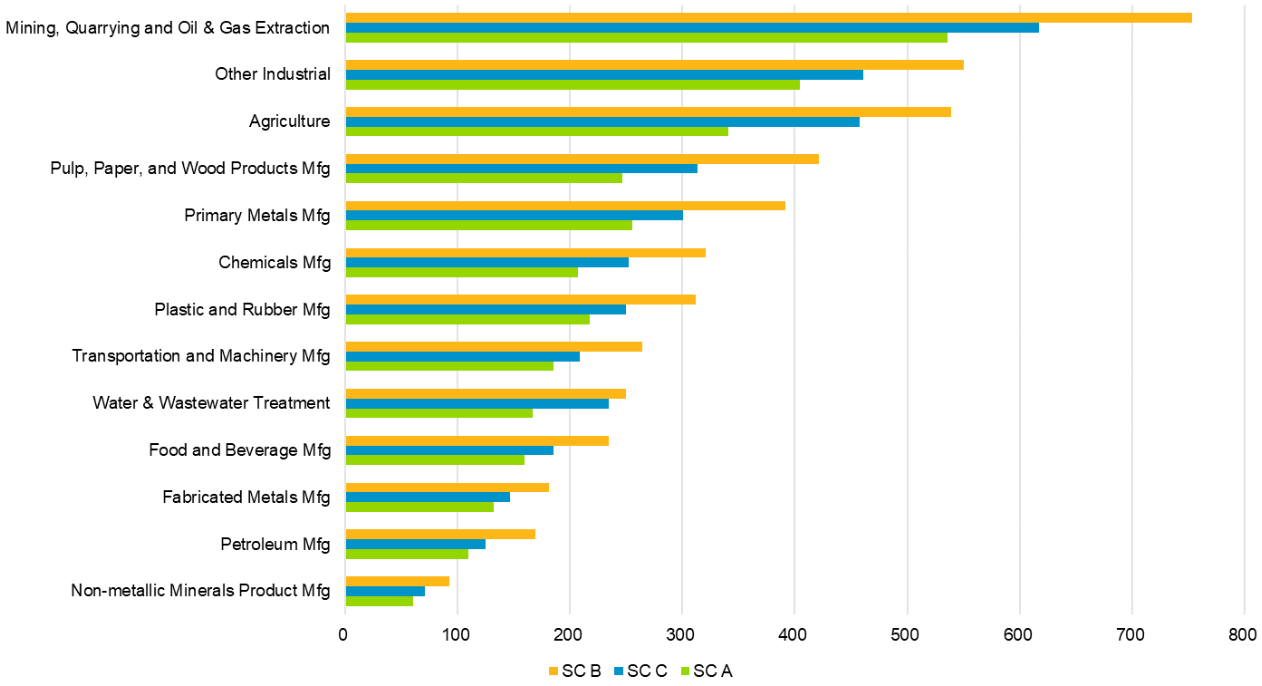


Source: Navigant analysis

Industrial Sector

Figure F-12 shows the total electric energy achievable savings potential for each customer segment and scenario in 2038. Although the agriculture segment is projected to have the highest potential as a percent of the reference forecast, the mining, quarrying and oil & gas extraction segment delivers the greatest absolute savings potential. This was due to this customer segment having significantly higher forecast electric energy sales as compared to the other customer segments.

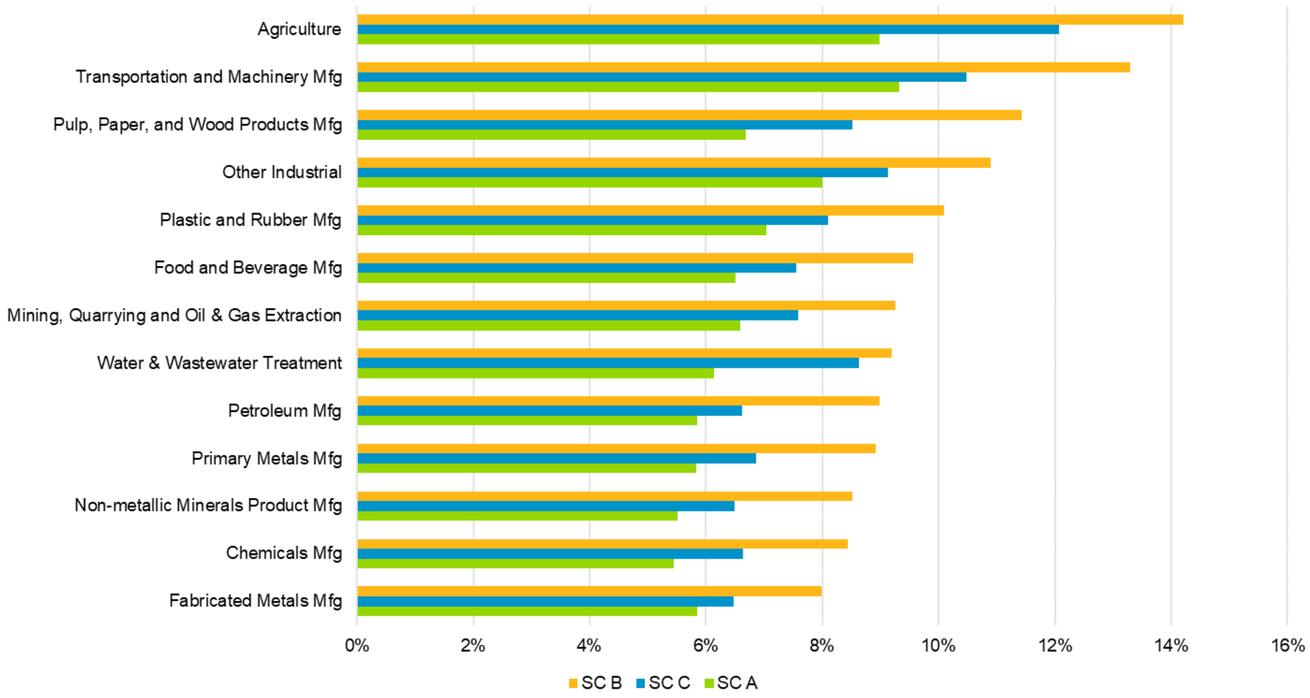
Figure F-12. Electric Energy Achievable Savings Potential by Customer Segment and Scenario in 2038 (GWh)



Source: Navigant analysis

Figure F-13 shows the electric energy achievable savings potential as a percent of the reference forecast across all customer segments and scenarios in 2038. The agriculture segment tops the list because the end uses with the highest absolute savings align with the end uses that make up the greatest portion of those segments' total forecast sales (e.g., lighting), whereas these same end uses make up less of the forecast sales for the other customer segments.

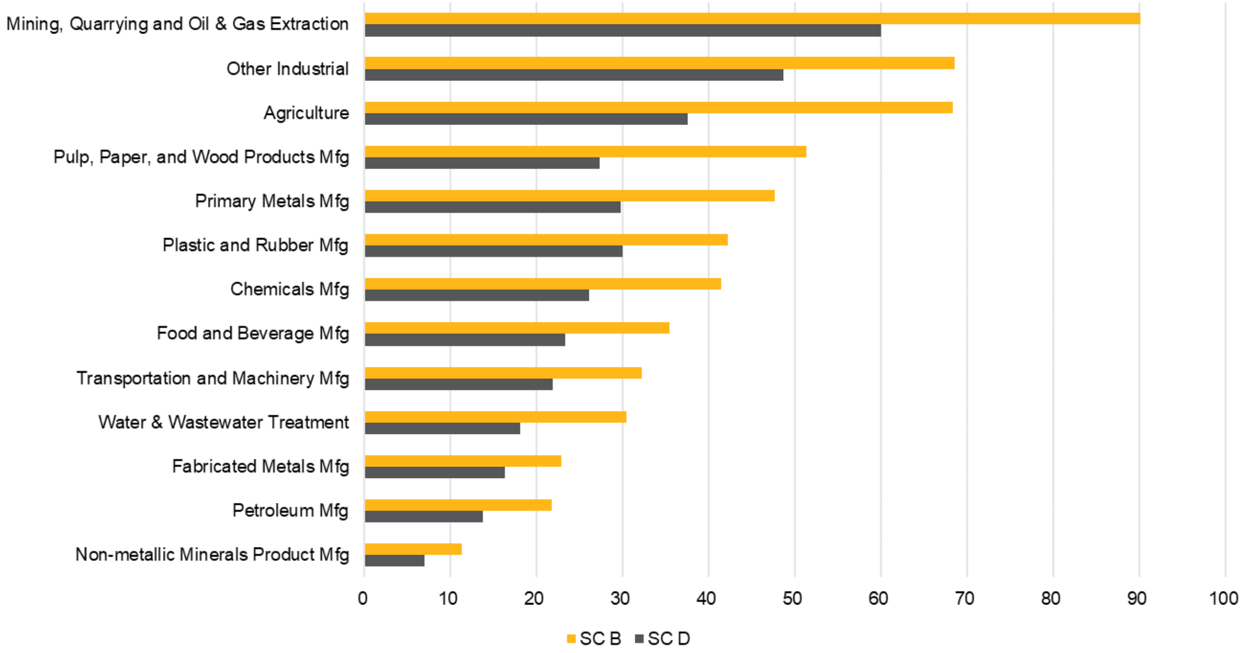
Figure F-13. Electric Energy Achievable Savings Potential as a Percent of Reference Forecast by Customer Segment and Scenario (%)



Source: Navigant analysis

Figure F-14 shows the total electric summer peak demand achievable savings potential for each customer segment and Scenarios B and D in 2038. Similar to the electric energy savings potential, the mining, quarrying and oil & gas extraction customer segment delivers the greatest demand savings potential.

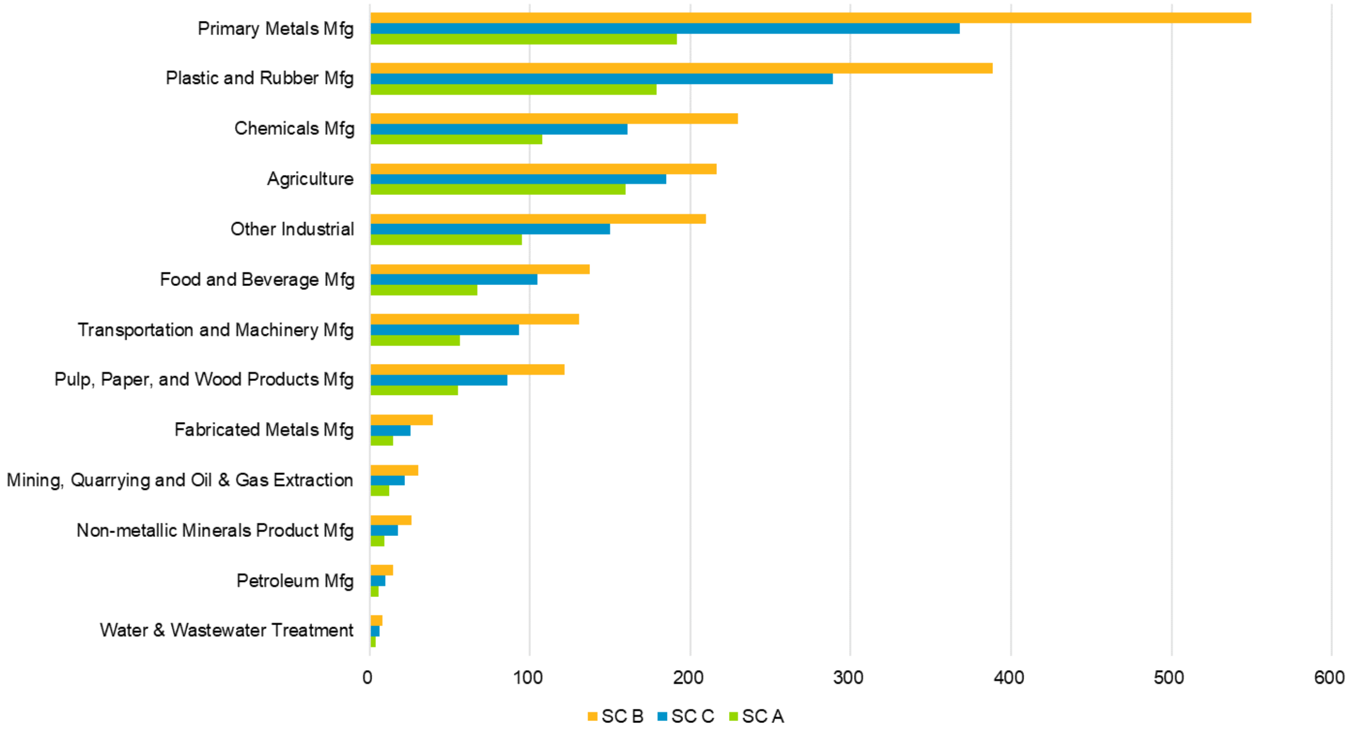
Figure F-14. Electric Summer Peak Demand Achievable Savings Potential by Customer Segment and Scenario in 2038 (MW)



Source: Navigant analysis

Figure F-15 shows the total natural gas energy achievable savings potential for each customer segment and scenario in 2038.

Figure F-15. Natural Gas Energy Achievable Savings Potential by Customer Segment and Scenario in 2038 (Million m^3)

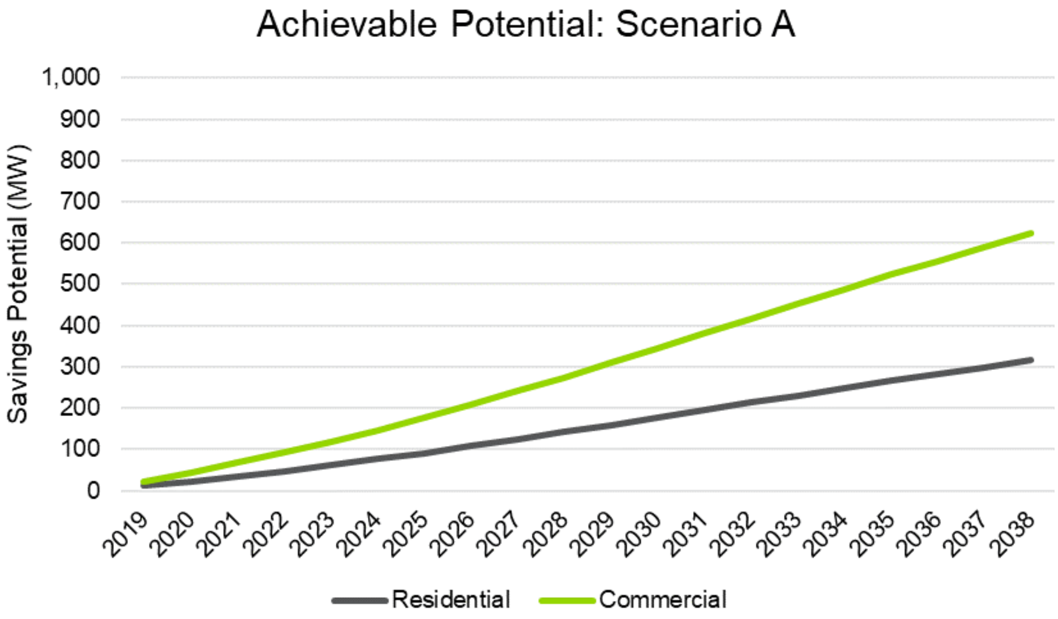


Source: Navigant analysis

F.2.2 Technically Feasible Demand Response

Figure F-16 shows the estimated technically feasible electric demand response[106] potential associated with measures adopted in Scenario A, across the potential reference forecast period for each sector.

Figure F-16. Electric Demand Response Economic Potential by Sector (MW) – Scenario A



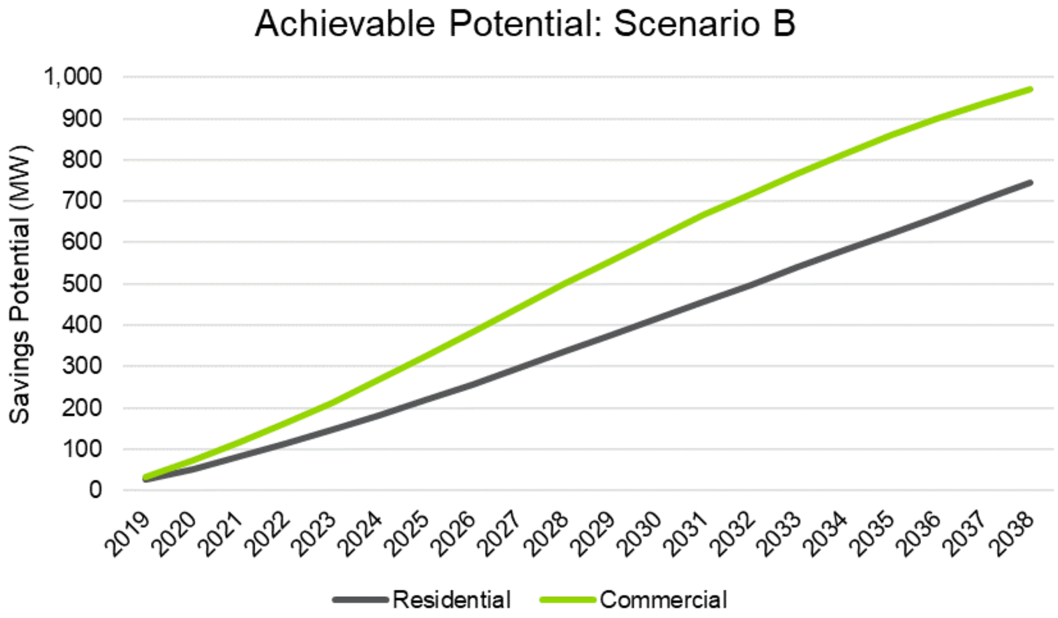
Source: Navigant analysis

Figure F-17 shows the estimated technically feasible electric demand response potential associated with measures adopted in Scenario B, across the potential reference forecast period for each sector.

---

[106] Note that this estimate of DR potential does not account for the incremental costs associated with implementing the necessary controls required to convert the energy efficiency measures (e.g., switches, software, other control infrastructure) and so must be understood to be the technical potential of DR associated with the economically feasible DR-capable energy efficiency measures.

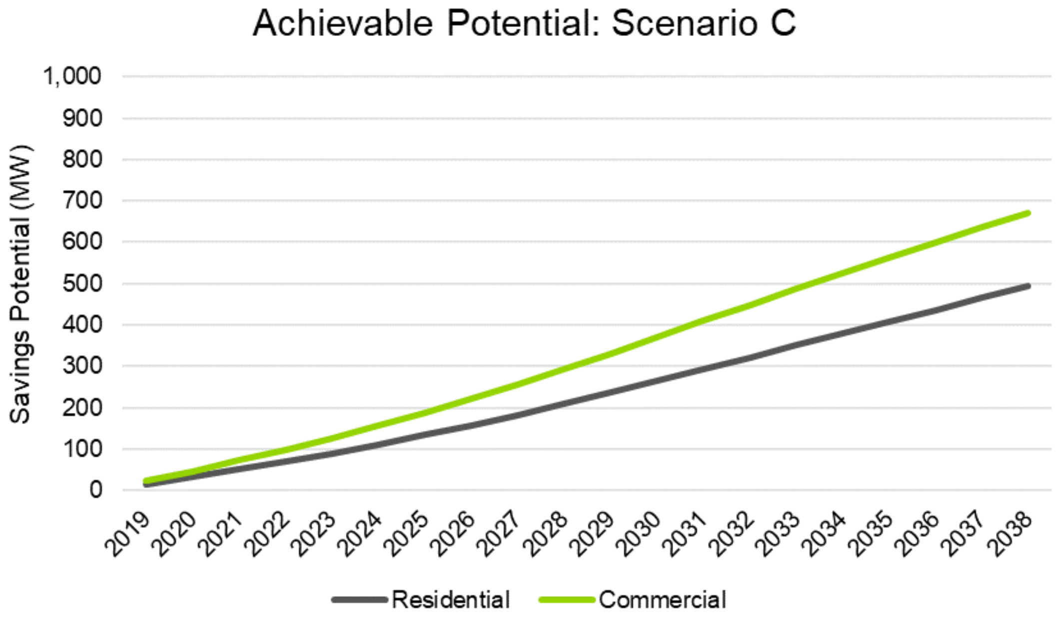
Figure F-17. Electric Demand Response Economic Potential by Sector (MW) – Scenario B



Source: Navigant analysis

Figure F-18 shows the estimated technically feasible electric demand response potential associated with measures adopted in Scenario C, across the potential reference forecast period for each sector.

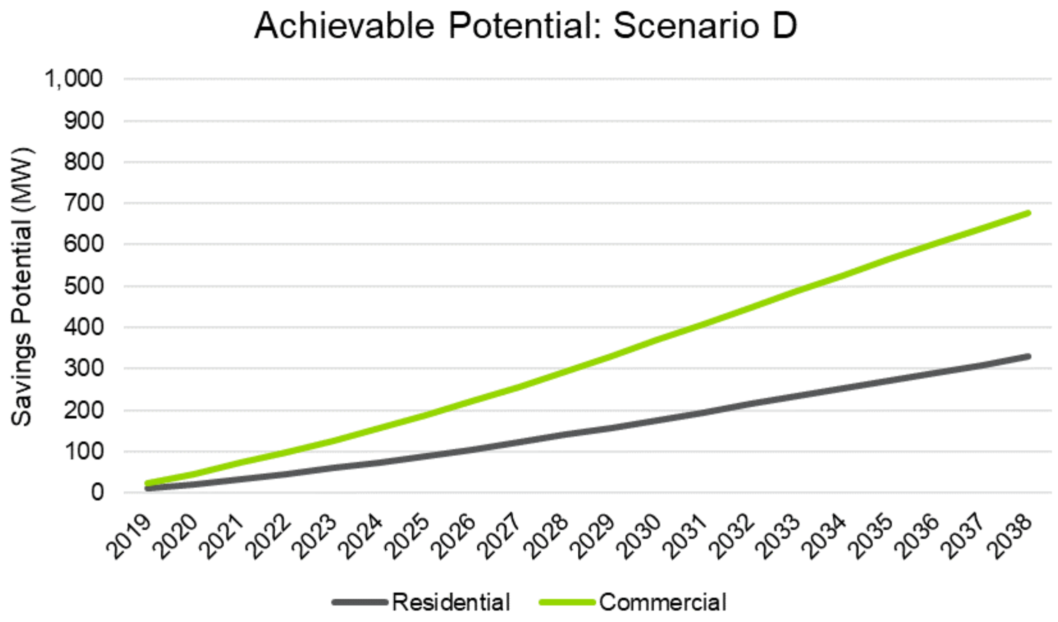
Figure F-18. Electric Demand Response Economic Potential by Sector (MW) – Scenario C



Source: Navigant analysis

Figure F-19 shows the estimated technically feasible electric demand response potential associated with measures adopted in Scenario D, across the potential reference forecast period for each sector.

Figure F-19. Electric Demand Response Economic Potential by Sector (MW) – Scenario D



Source: Navigant analysis

F.2.3 Scenario A Cost Curve Results

This section of the appendix, and those that follow, provides the cost curve results calculated by the model. These are shown at the portfolio level for each scenario for both natural gas and electric energy.

These curves present the total program costs (incentives and administrative costs) spent to support the adoption of all measures installed previous to, and including the year shown, on the y-axis. These program costs are referred to in the axis title as “budget” for the sake of concision.

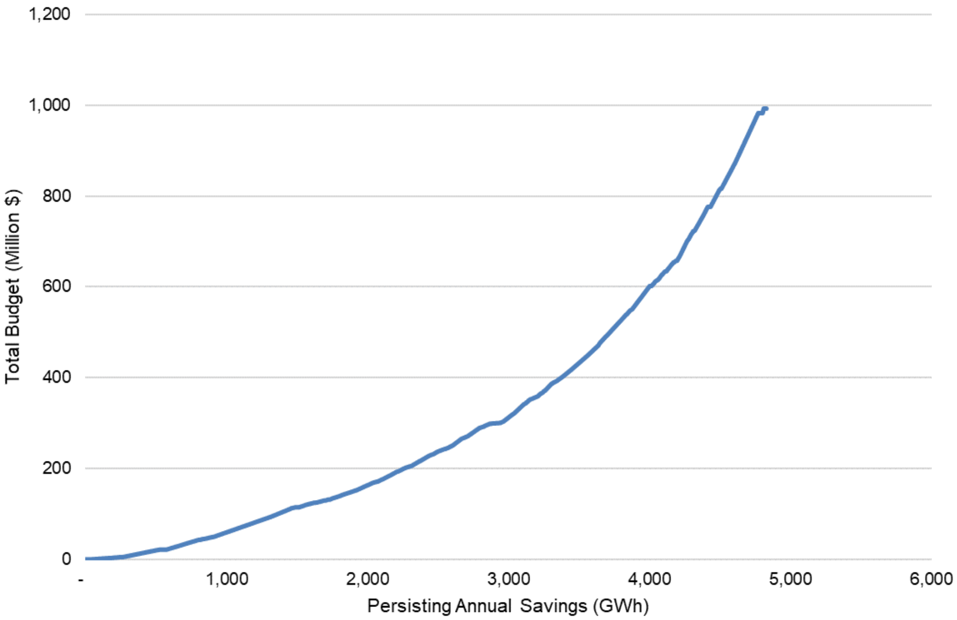
The potential on the x-axis represents the annual energy savings delivered in that year by all measures installed previous to, and including, the year shown.

Note that in all figures, the annual achievable potential accumulates from the left to the right side of the plot.

When looking at the electric energy cost curves across each of the three years shown (2023, 2030, and 2038), in each case 50% of the total potential shown can be achieved by spending approximately 20% of total program costs in that year. With respect to the natural gas cost curves, 50% of the potential shown in a given year is achieved by spending approximately 37% of the total costs shown in that year.

Figure F-20 shows the cost curve for electric energy in 2023 under Scenario A.

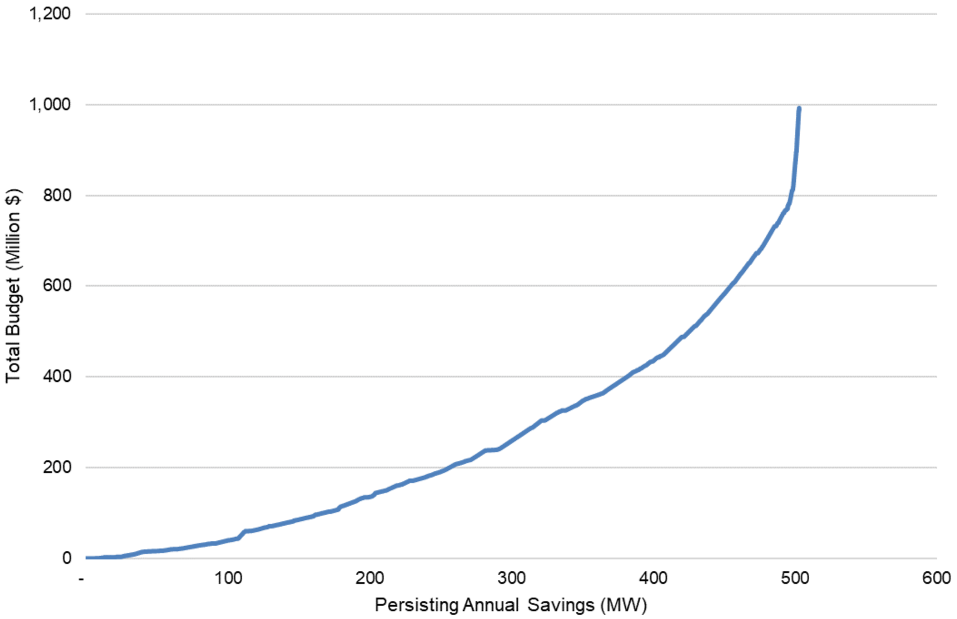
Figure F-20. Electric Energy Cost Curve, Scenario A in 2023



Source: Navigant analysis

Figure F-21 shows the cost curve for electric summer peak demand in 2023 under Scenario A.

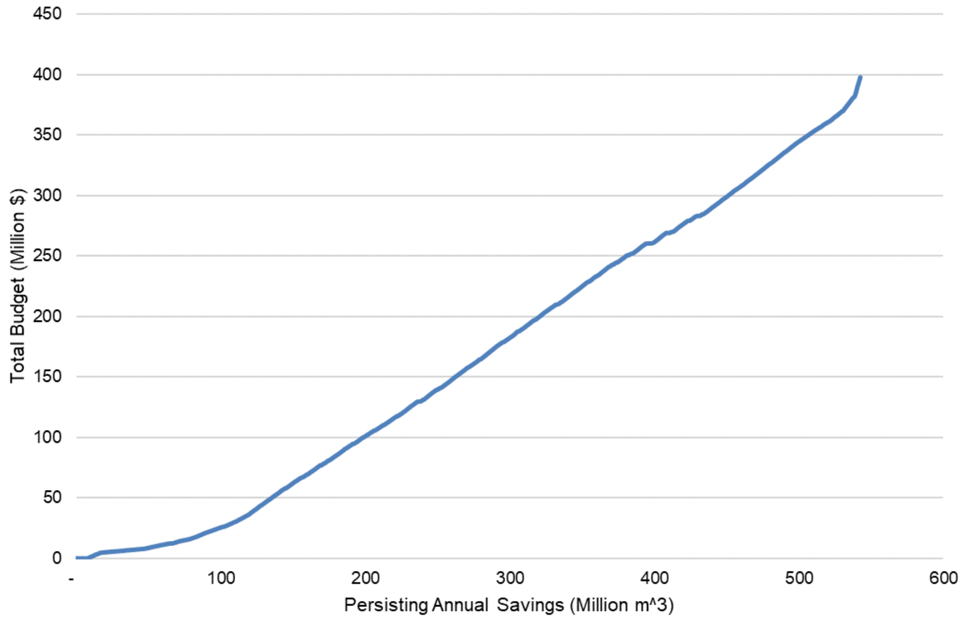
Figure F-21. Electric Summer Peak Demand Cost Curve, Scenario A in 2023



Source: Navigant analysis

Figure F-22 shows the cost curve for natural gas energy in 2023 under Scenario A.

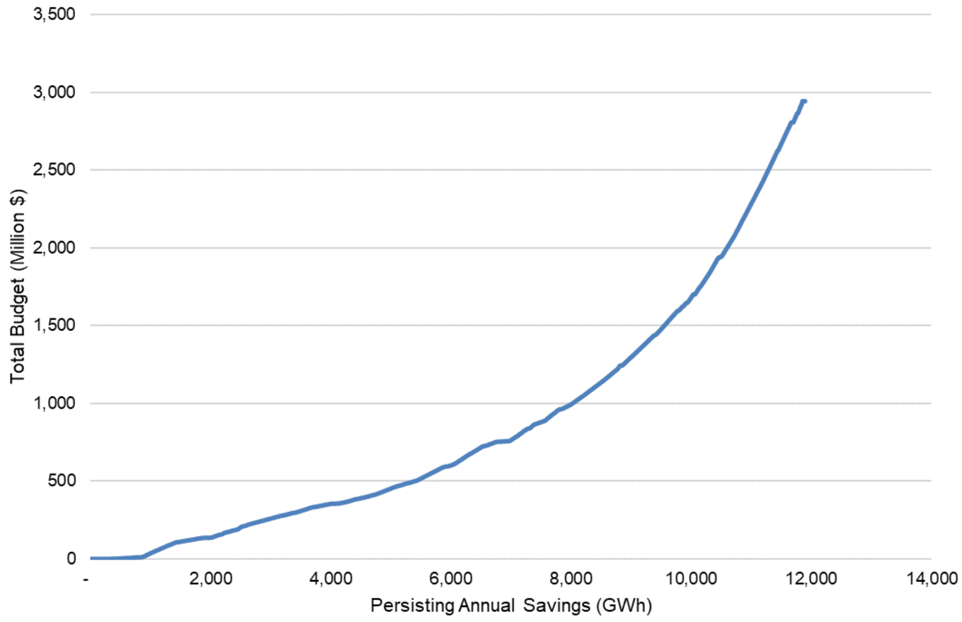
Figure F-22. Natural Gas Energy Cost Curve, Scenario A in 2023



Source: Navigant analysis

Figure F-23 shows the cost curve for electric energy in 2030 under Scenario A.

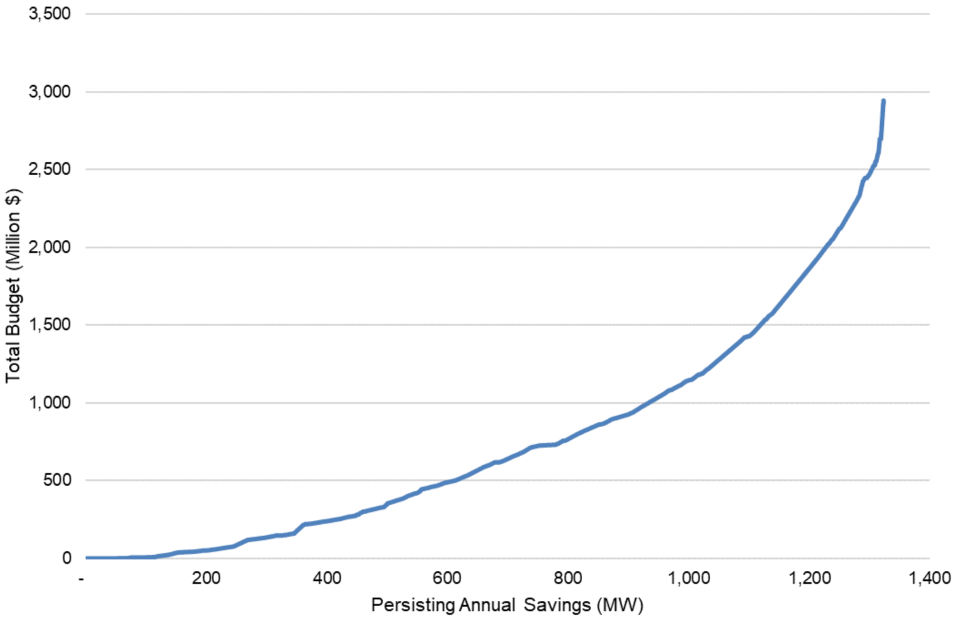
Figure F-23. Electric Energy Cost Curve, Scenario A in 2030



Source: Navigant analysis

Figure F-25 shows the cost curve for electric summer peak demand in 2030 under Scenario A.

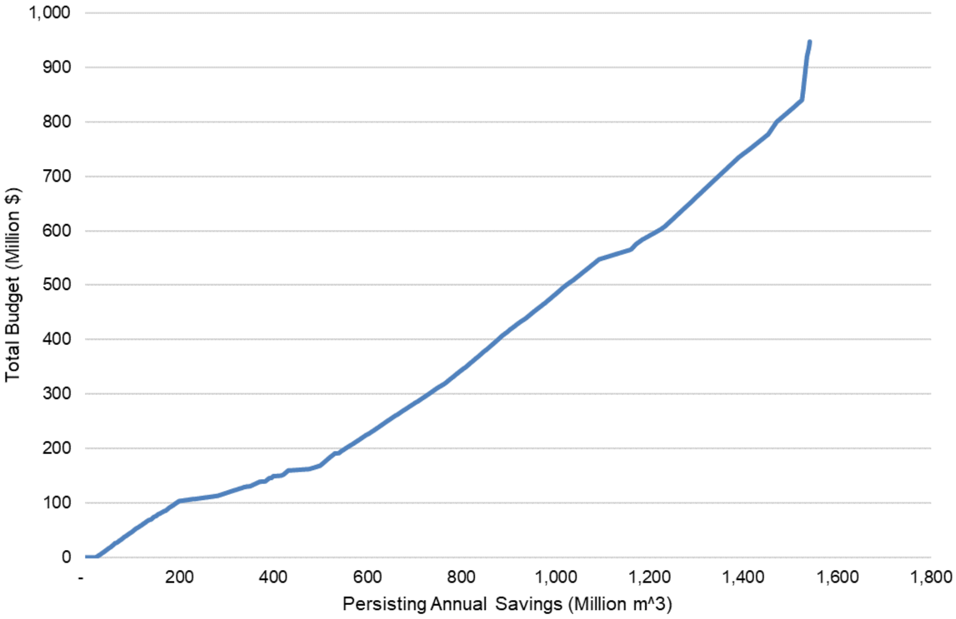
Figure F-24. Electric Summer Peak Demand Cost Curve, Scenario A in 2030



Source: Navigant analysis

Figure F-25 shows the cost curve for natural gas energy in 2030 under Scenario A.

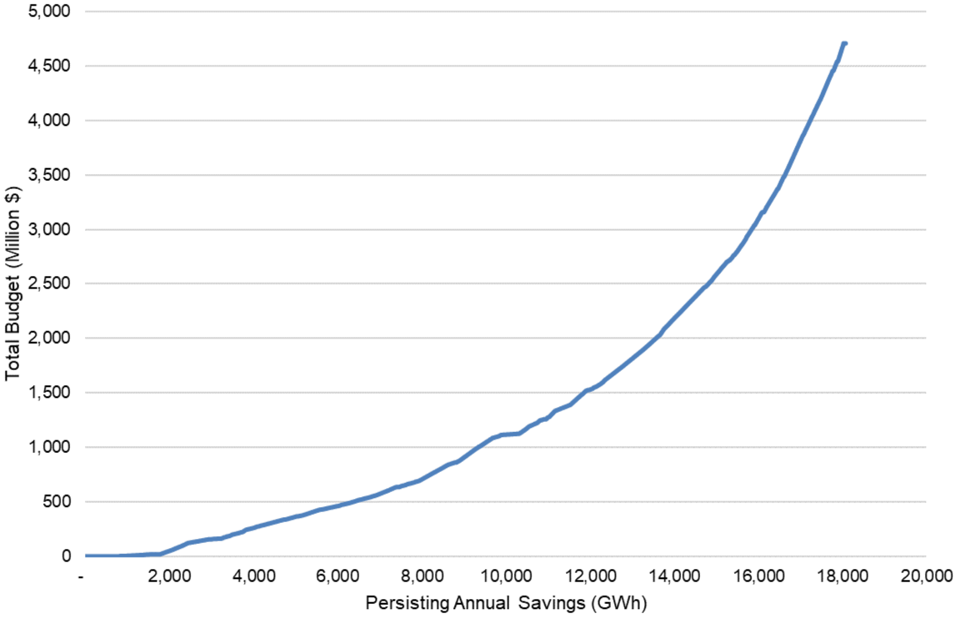
Figure F-25. Natural Gas Energy Cost Curve, Scenario A in 2030



Source: Navigant analysis

Figure F-26 shows the cost curve for electric energy in 2038 under Scenario A.

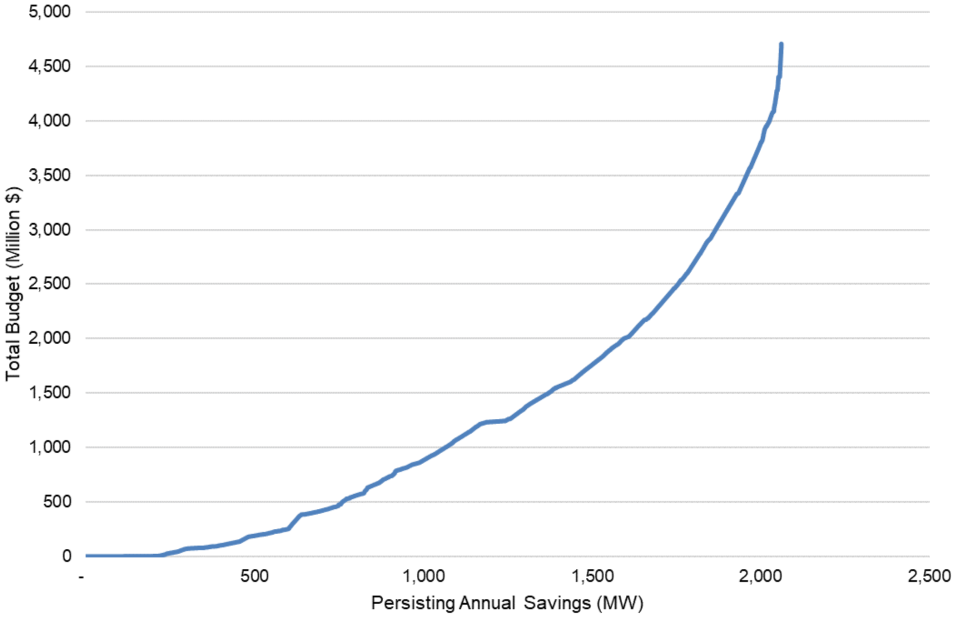
Figure F-26. Electric Energy Cost Curve, Scenario A in 2038



Source: Navigant analysis

Figure F-27 shows the cost curve for electric summer peak demand in 2038 under Scenario A.

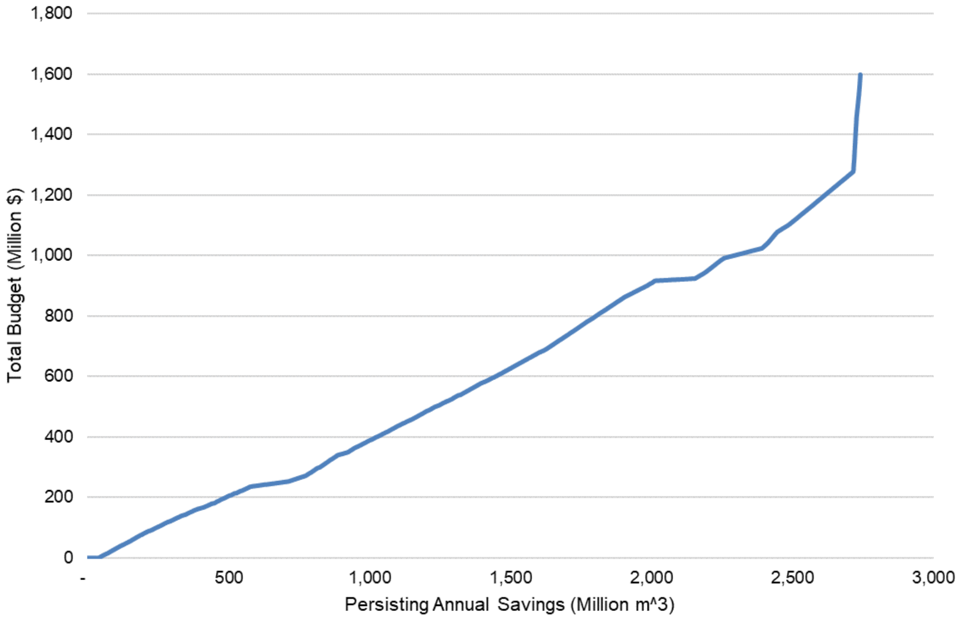
Figure F-27. Electric Summer Peak Demand Cost Curve, Scenario A in 2038



Source: Navigant analysis

Figure F-28 shows the cost curve for natural gas energy in 2038 under Scenario A.

Figure F-28. Natural Gas Energy Cost Curve, Scenario A in 2038



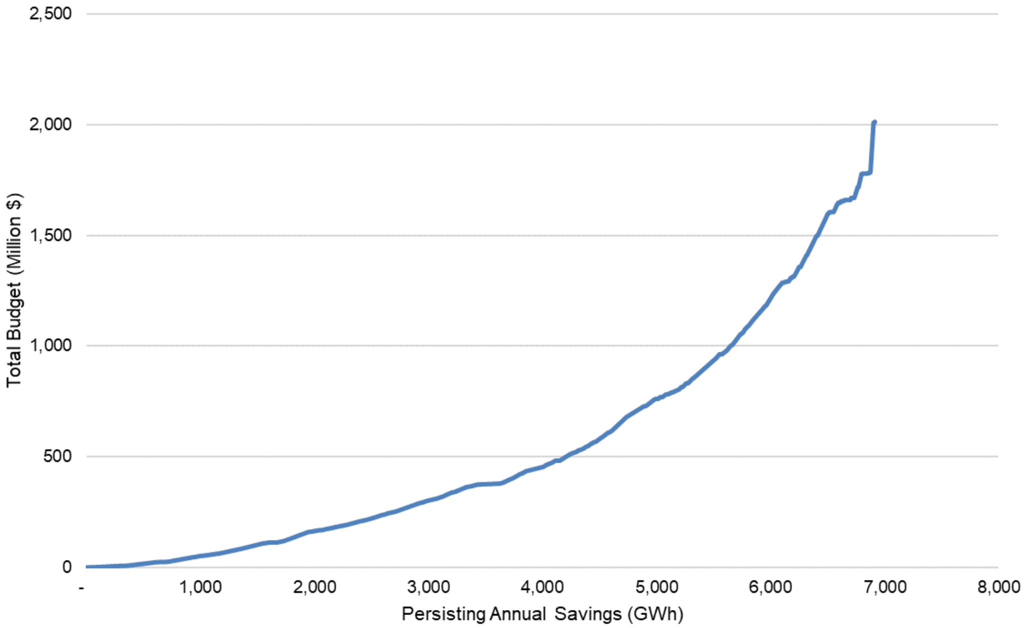
Source: Navigant analysis

F.2.4 Scenario B Cost Curve Results

When looking at the electric energy cost curves across each of the three years shown (2023, 2030, and 2038), in each case 50% of the total potential shown can be achieved by spending approximately 18% of total program costs in that year. With respect to the natural gas cost curves, 50% of the potential shown in a given year is achieved by spending approximately 22% of the total program costs shown in that year.

Figure F-29 shows the cost curve for electric energy in 2023 under Scenario B.

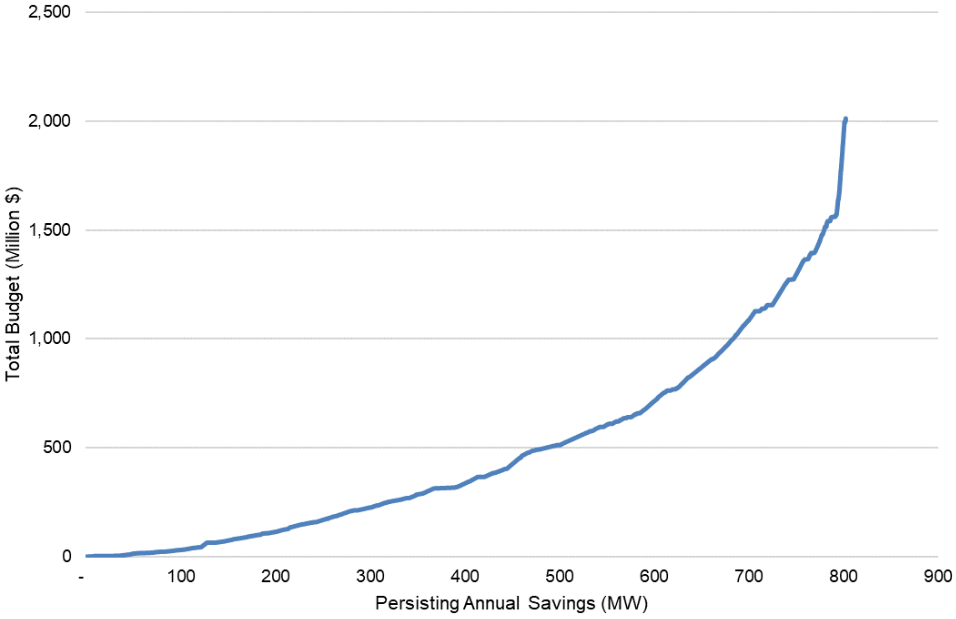
Figure F-29. Electric Energy Cost Curve, Scenario B in 2023



Source: Navigant analysis

Figure F-30 shows the cost curve for electric summer peak demand in 2023 under Scenario B.

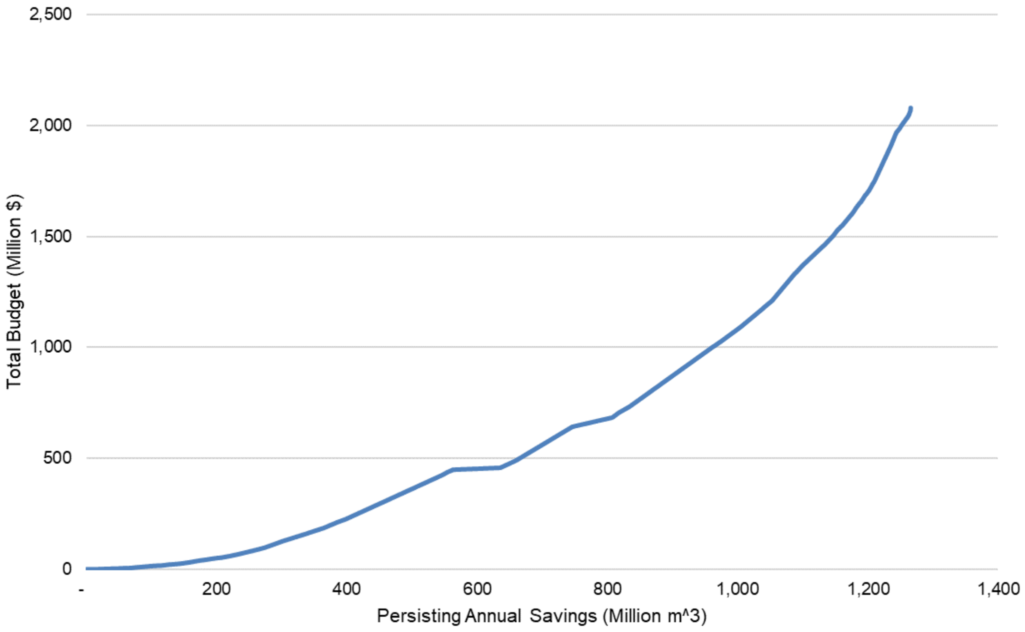
Figure F-30. Electric Summer Peak Demand Cost Curve, Scenario B in 2023



Source: Navigant analysis

Figure F-31 shows the cost curve for natural gas energy in 2023 under Scenario B.

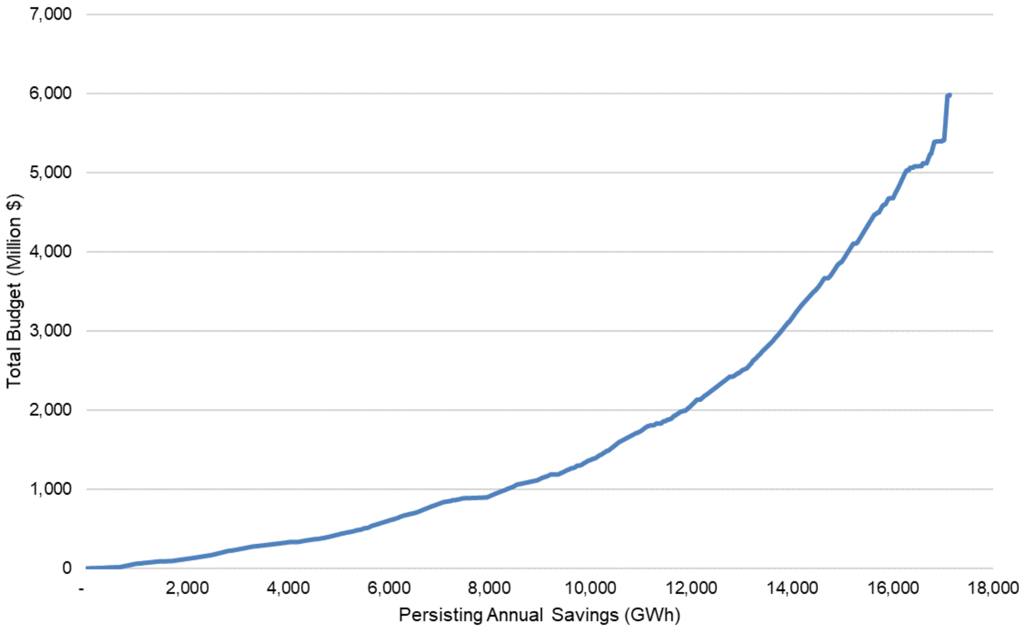
Figure F-31. Natural Gas Energy Cost Curve, Scenario B in 2023



Source: Navigant analysis

Figure F-32 shows the cost curve for electric energy in 2030 under Scenario B.

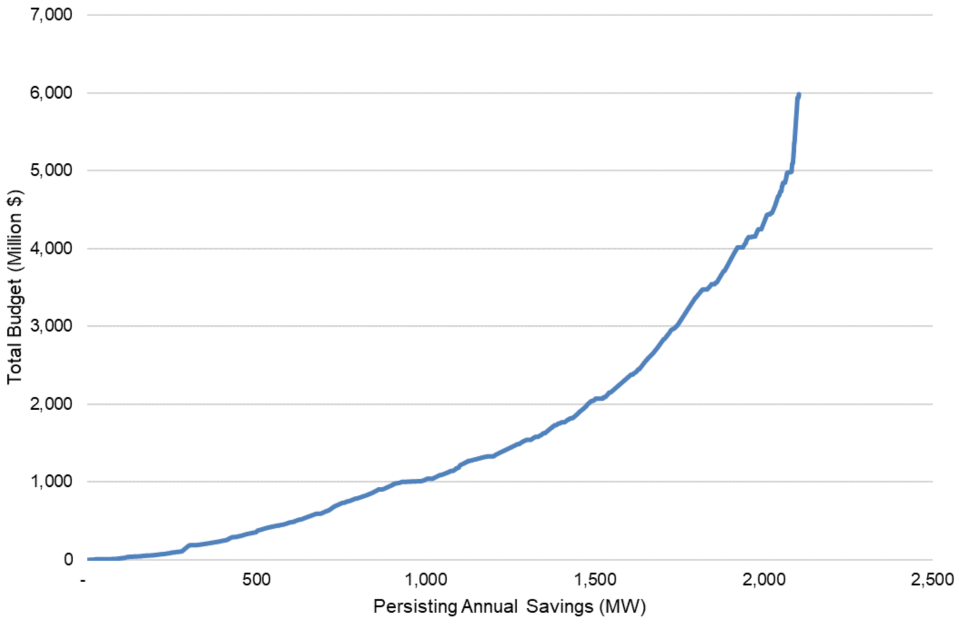
Figure F-32. Electric Energy Cost Curve, Scenario B in 2030



Source: Navigant analysis

Figure F-33 shows the cost curve for electric summer peak demand in 2030 under Scenario B.

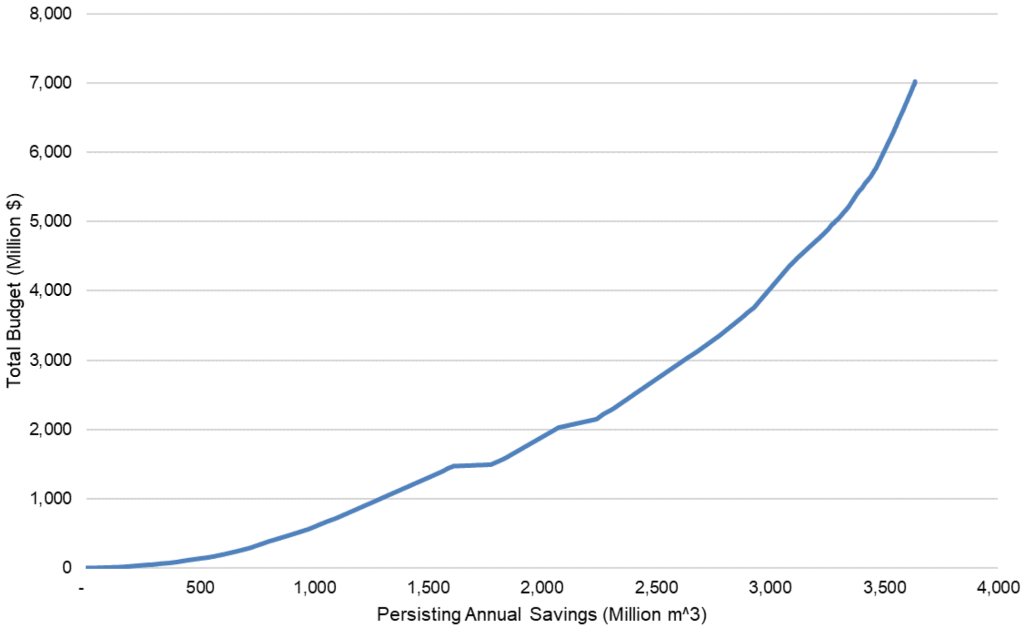
Figure F-33. Electric Summer Peak Demand Cost Curve, Scenario B in 2030



Source: Navigant analysis

Figure F-34 shows the cost curve for natural gas energy in 2030 under Scenario B.

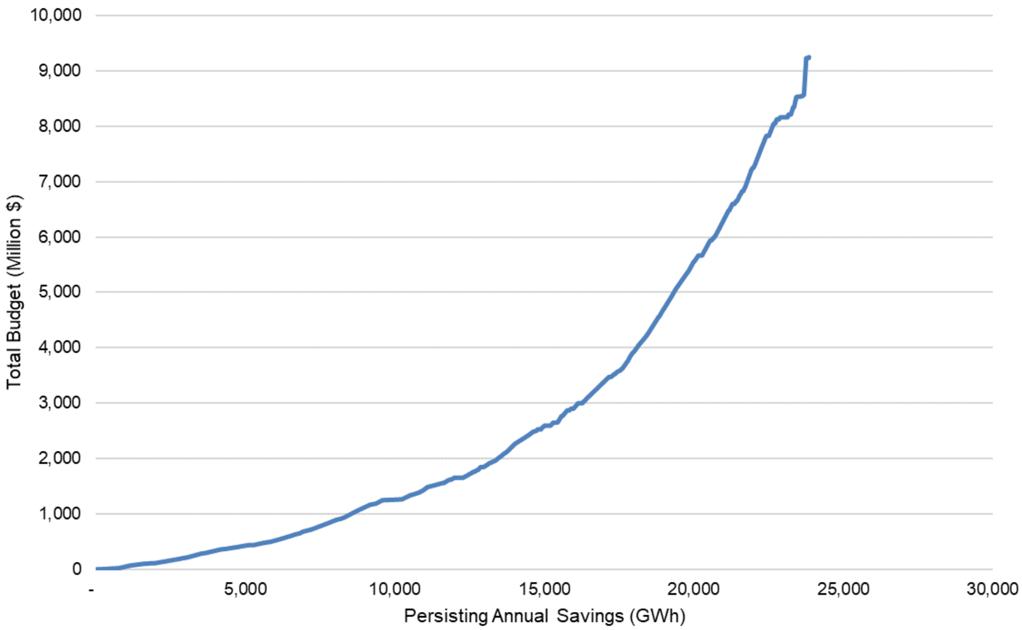
Figure F-34. Natural Gas Energy Cost Curve, Scenario B in 2030



Source: Navigant analysis

Figure F-35 shows the cost curve for electric energy in 2038 under Scenario B.

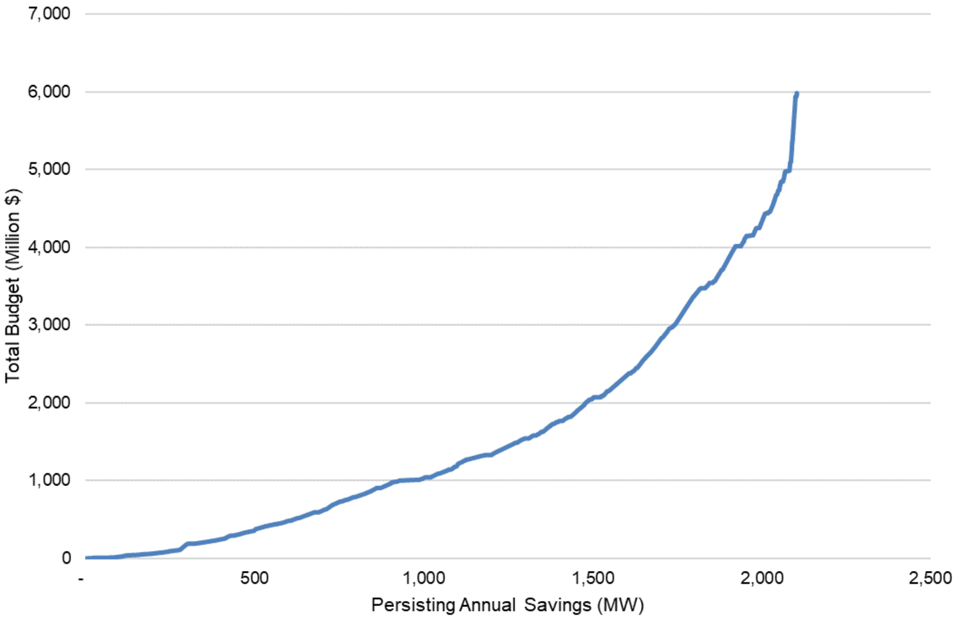
Figure F-35. Electric Energy Cost Curve, Scenario B in 2038



Source: Navigant analysis

Figure F-41 shows the cost curve for electric summer peak demand in 2038 under Scenario B.

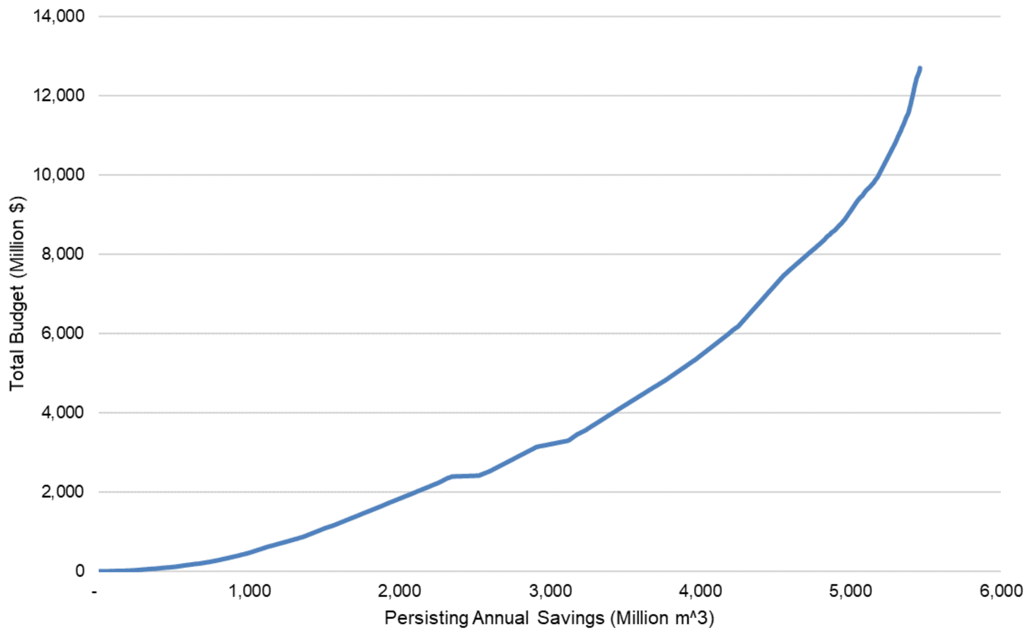
Figure F-36. Electric Summer Peak Demand Cost Curve, Scenario B in 2038



Source: Navigant analysis

Figure F-37 shows the cost curve for natural gas energy in 2038 under Scenario B.

Figure F-37. Natural Gas Energy Cost Curve, Scenario B in 2038



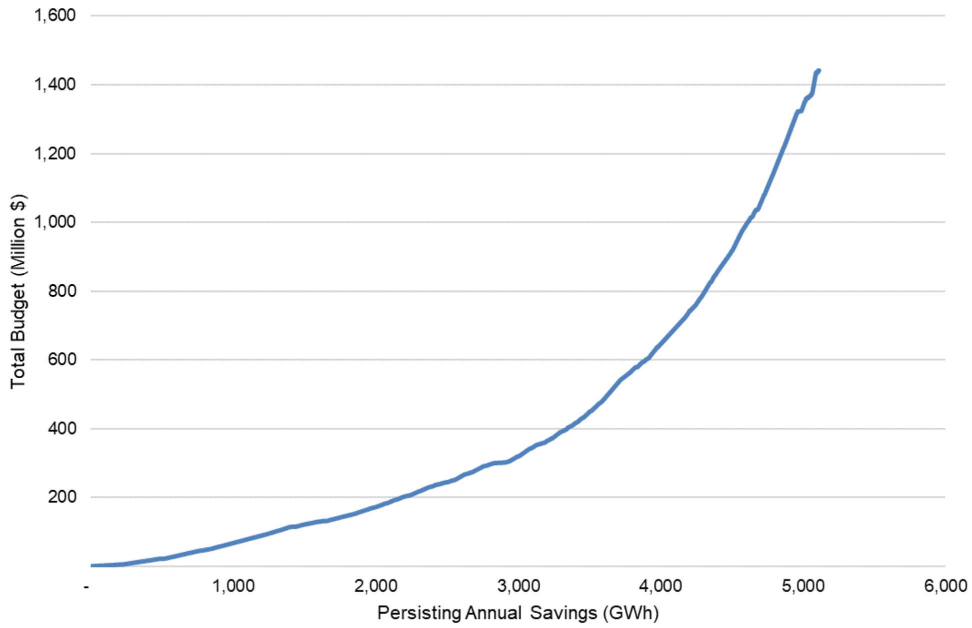
Source: Navigant analysis

F.2.5 Scenario C Cost Curve Results

When looking at the electric energy cost curves across each of the three years shown (2023, 2030, and 2038), 50% of the total potential shown can be achieved by spending approximately 17%, 28%, and 15% of total program costs, respectively. With respect to the natural gas cost curves, 50% of the potential shown in a given year is achieved by spending approximately 34% of the total program costs shown in that year.

Figure F-38 shows the cost curve for electric energy in 2023 under Scenario C.

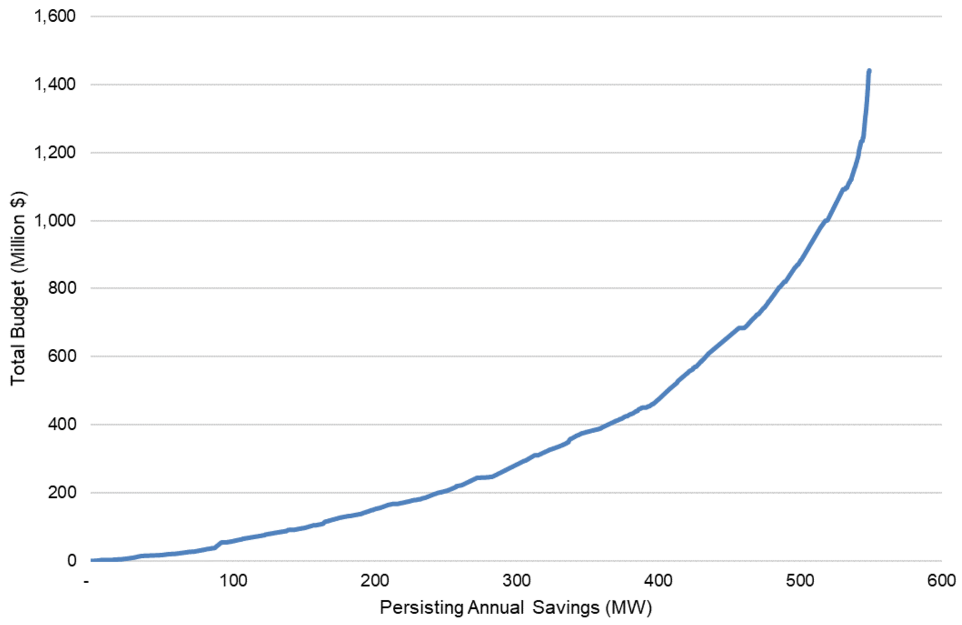
Figure F-38. Electric Energy Cost Curve, Scenario C in 2023



Source: Navigant analysis

Figure F-46 shows the cost curve for electric summer peak demand in 2023 under Scenario C.

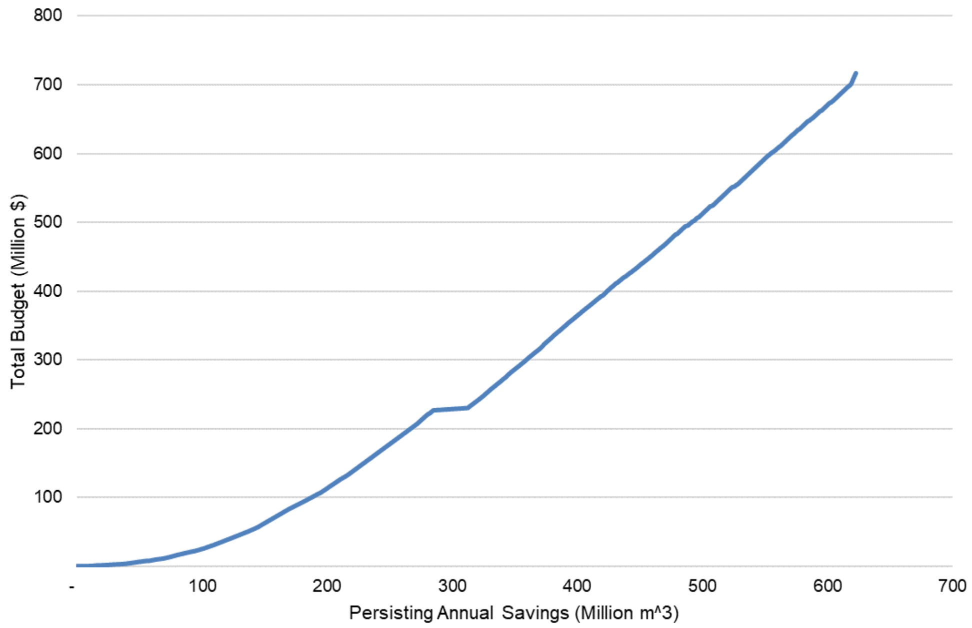
Figure F-39. Electric Summer Peak Demand Cost Curve, Scenario C in 2023



Source: Navigant analysis

Figure F-40 shows the cost curve for natural gas energy in 2023 under Scenario C.

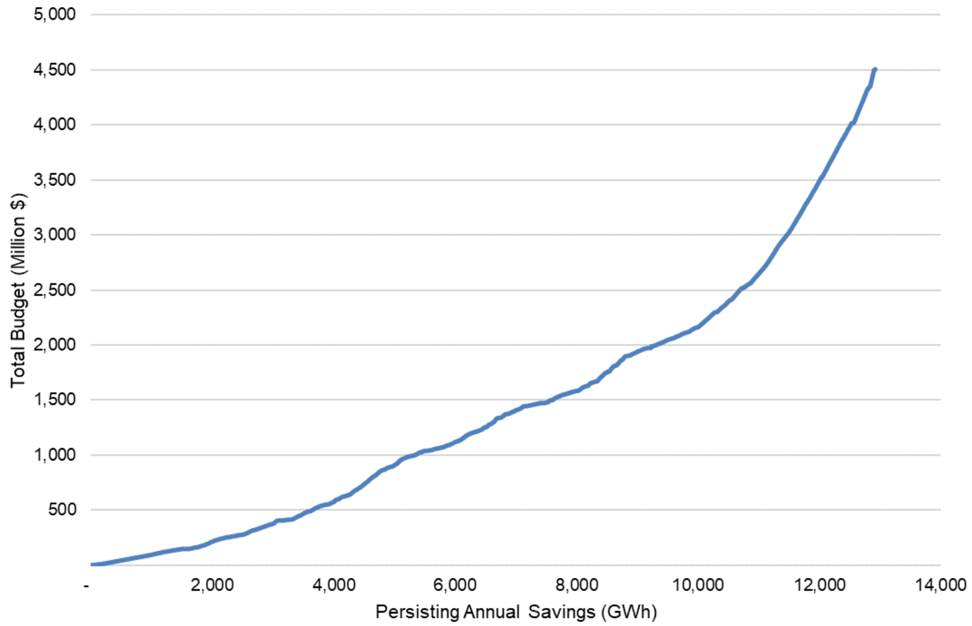
Figure F-40. Natural Gas Energy Cost Curve, Scenario C in 2023



Source: Navigant analysis

Figure F-41 shows the cost curve for electric energy in 2030 under Scenario C.

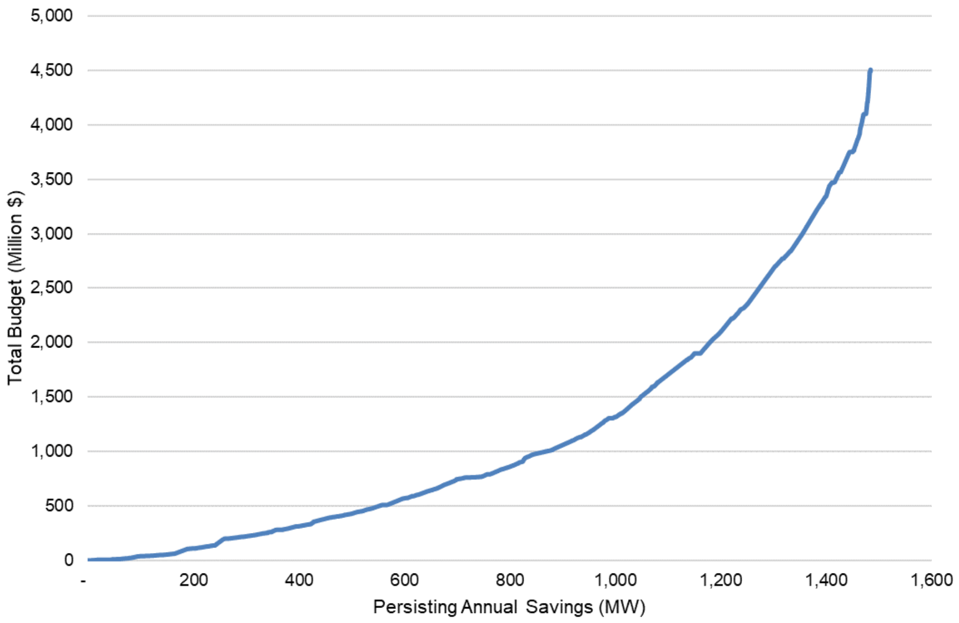
Figure F-41. Electric Energy Cost Curve, Scenario C in 2030



Source: Navigant analysis

Figure F-51 shows the cost curve for electric summer peak demand in 2030 under Scenario C.

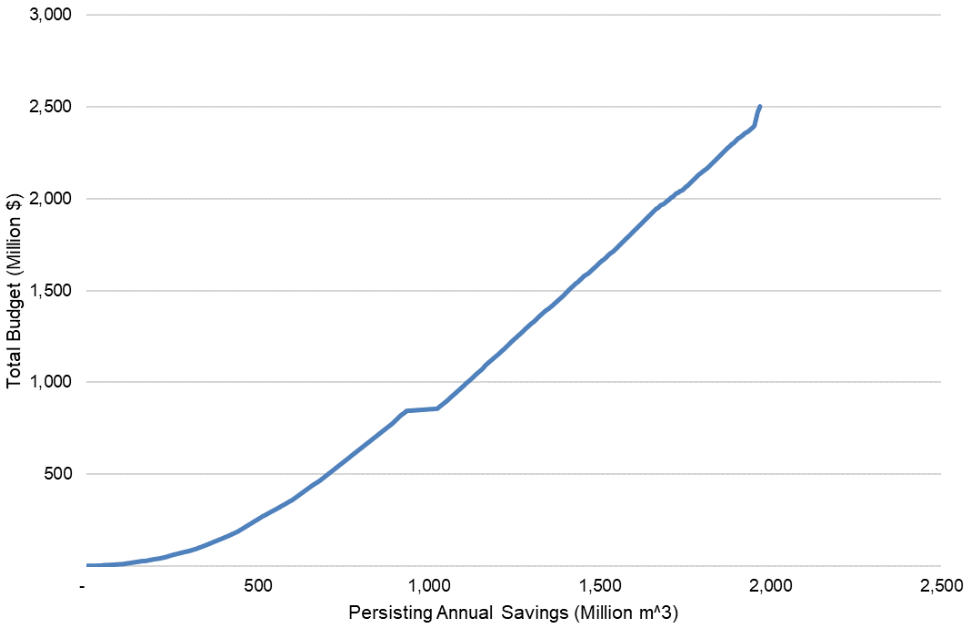
Figure F-42. Electric Summer Peak Demand Cost Curve, Scenario C in 2030



Source: Navigant analysis

Figure F-43 shows the cost curve for natural gas energy in 2030 under Scenario C.

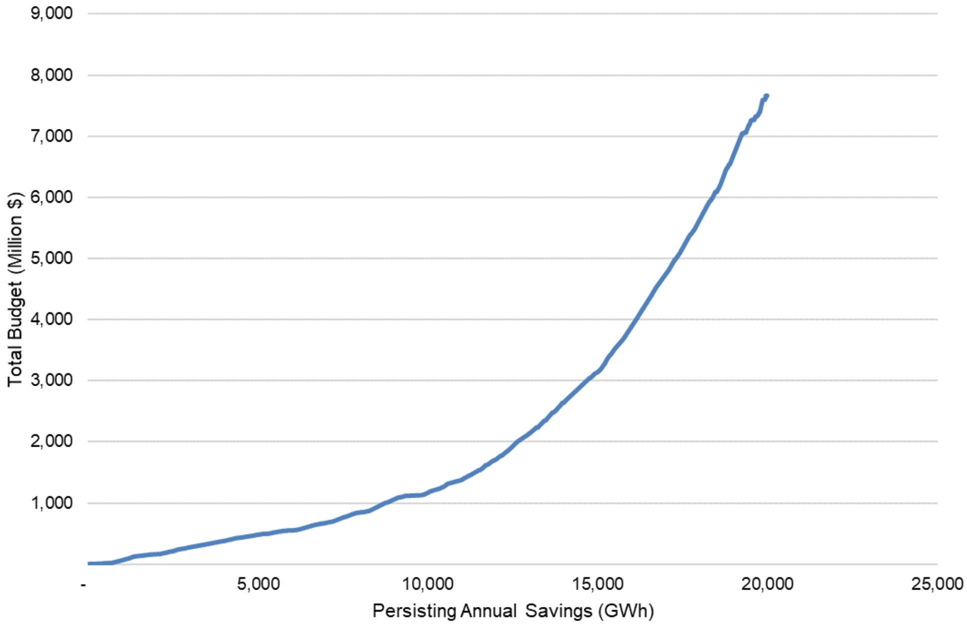
Figure F-43. Natural Gas Energy Cost Curve, Scenario C in 2030



Source: Navigant analysis

Figure F-44 shows the cost curve for electric energy in 2038 under Scenario C.

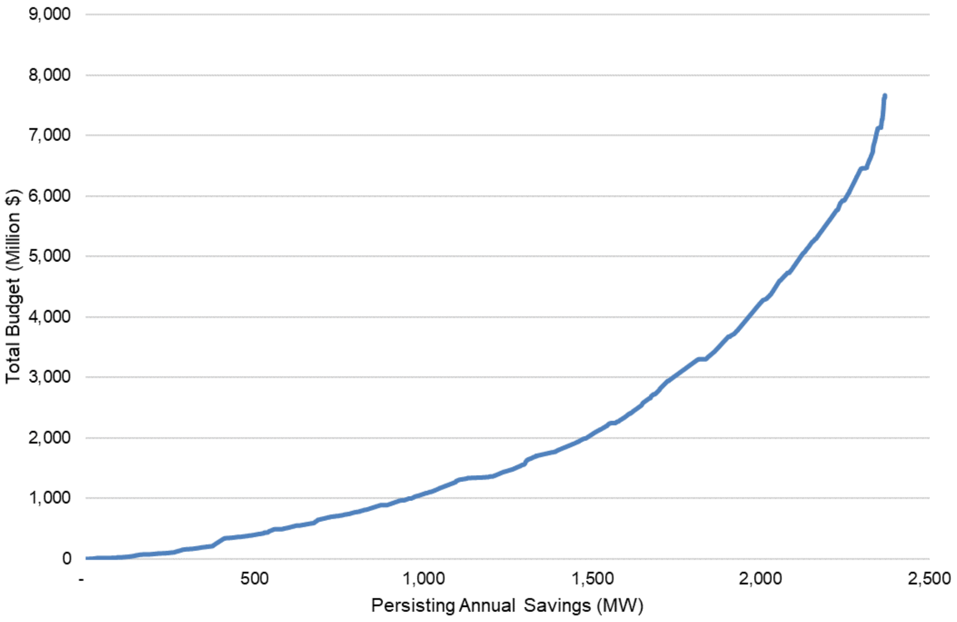
Figure F-44. Electric Energy Cost Curve, Scenario C in 2038



Source: Navigant analysis

Figure F-45 shows the cost curve for electric summer peak demand in 2038 under Scenario C.

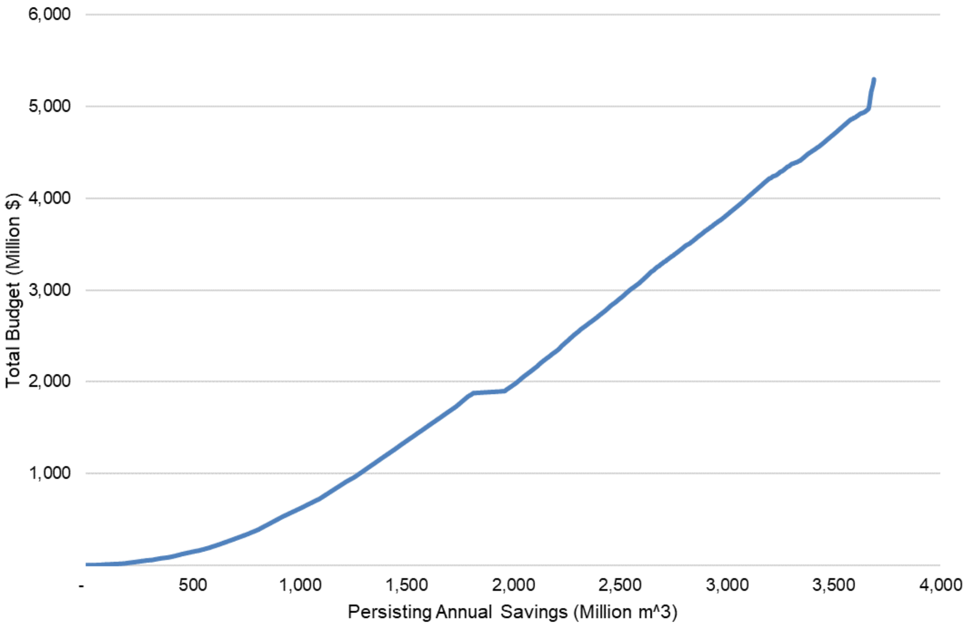
Figure F-45. Electric Summer Peak Demand Cost Curve, Scenario C in 2038



Source: Navigant analysis

Figure F-46 shows the cost curve for natural gas energy in 2038 under Scenario C.

Figure F-46. Natural Gas Energy Cost Curve, Scenario C in 2038



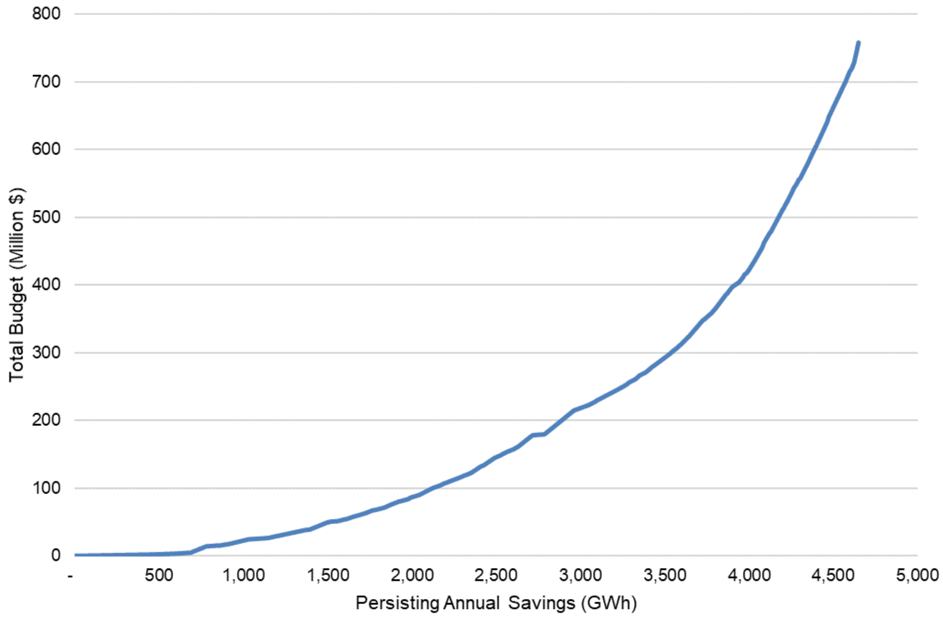
Source: Navigant analysis

F.2.6 Scenario D Cost Curve Results

When looking at the electric energy cost curves across each of the three years shown (2023, 2030, and 2038), in each case 50% of the total potential shown can be achieved by spending approximately 16% of total program costs in that year.

Figure F-47 shows the cost curve for electric energy in 2023 under Scenario D.

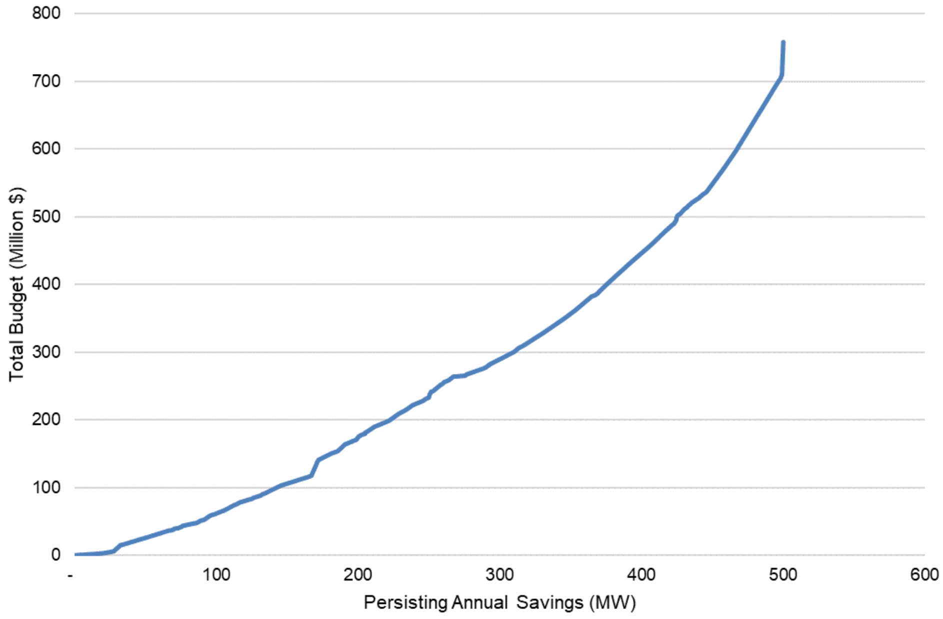
Figure F-47. Electric Energy Cost Curve, Scenario D in 2023



Source: Navigant analysis

Figure F-48 shows the cost curve for electric summer peak demand in 2023 under Scenario D.

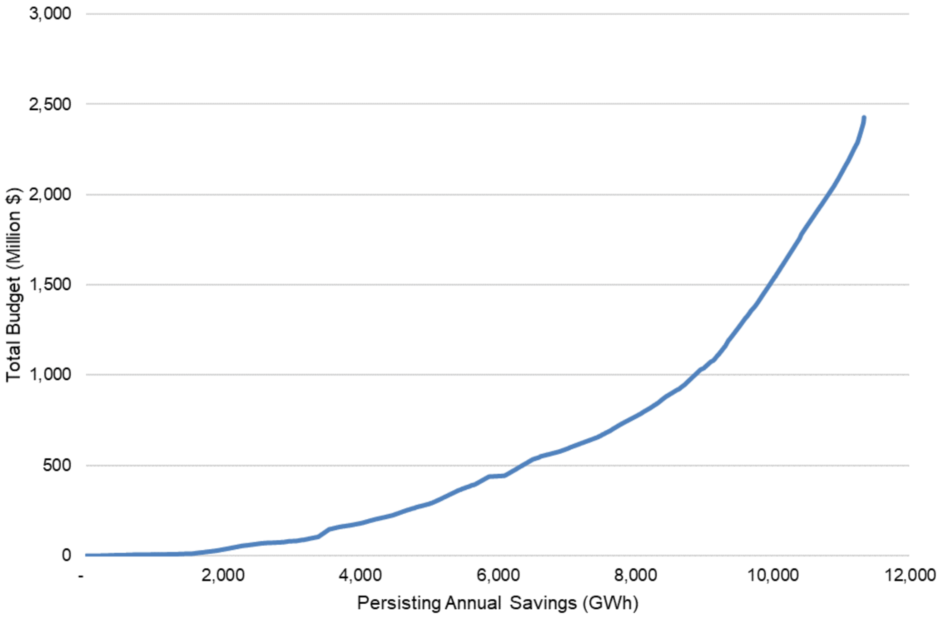
Figure F-48. Electric Summer Peak Demand Cost Curve, Scenario D in 2023



Source: Navigant analysis

Figure F-49 shows the cost curve for electric energy in 2030 under Scenario D.

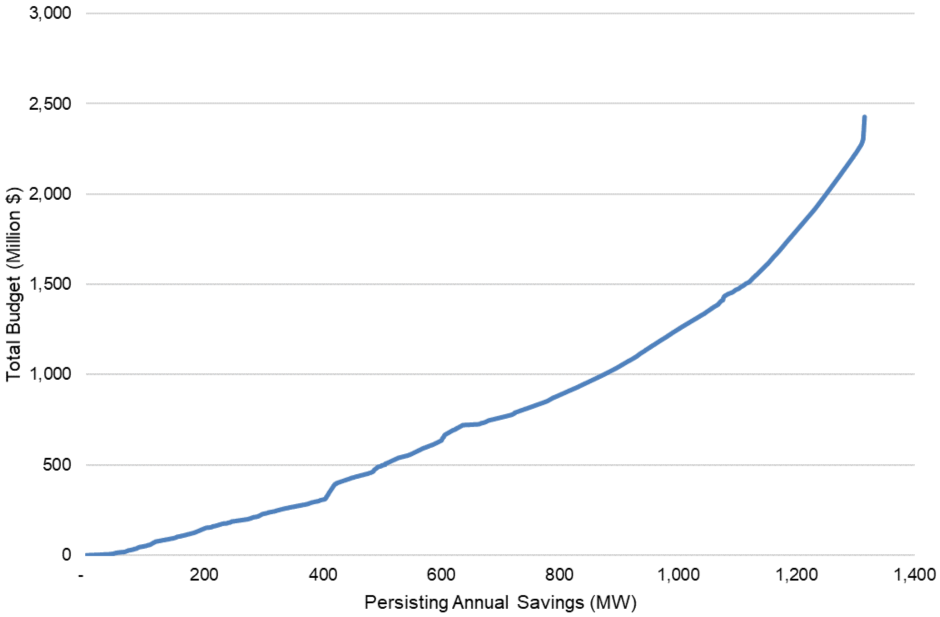
Figure F-49. Electric Energy Cost Curve, Scenario D in 2030



Source: Navigant analysis

Figure F-50 shows the cost curve for electric summer peak demand in 2030 under Scenario D.

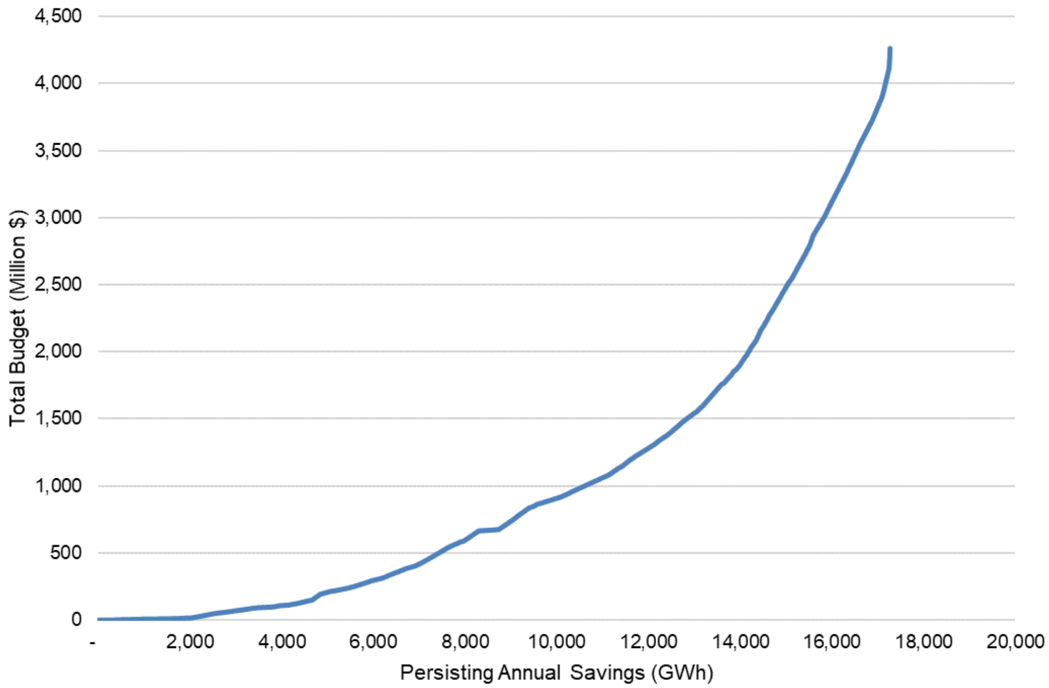
Figure F-50. Electric Summer Peak Demand Cost Curve, Scenario D in 2030



Source: Navigant analysis

Figure F-51 shows the cost curve for electric energy in 2038 under Scenario D.

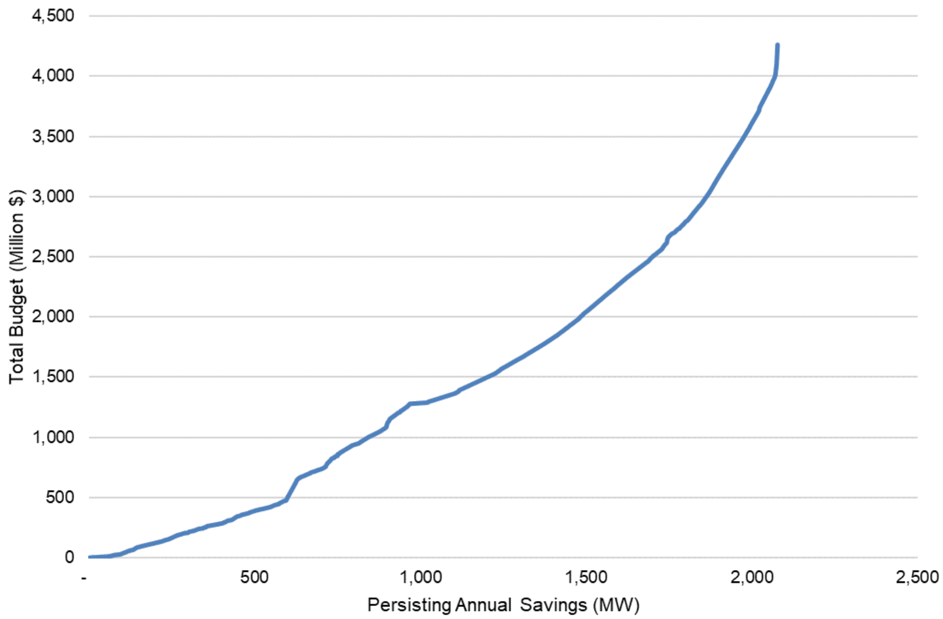
Figure F-51. Electric Energy Cost Curve, Scenario D in 2038



Source: Navigant analysis

Figure F-52 shows the cost curve for electric summer peak demand in 2038 under Scenario D.

Figure F-52. Electric Summer Peak Demand Cost Curve, Scenario D in 2038



Source: Navigant analysis

Appendix G. WHOLE BUILDING ANALYSIS

G.1 Detailed Methodology

G.1.1 Data Availability and Segment Selection

Navigant considered the following potential data sources for the analysis:

- Broader Public-Sector (BPS)
- Toronto Regional Conservation Authority's (TRCA) Greening Healthcare Program
- Green Hospital Scorecards (GHS)
- Toronto Tower Renewal
- Building Owners and Managers Association (BOMA) International
- Toronto District School Board

Aside from the BPS data, the other data are not publicly available and posed challenges with confidentiality as well as geographic coverage, in that they did not cover the entire province. Hence it was determined that the BPS data was the best available option under the circumstances and would also allow for re-producibility or enhancements to the analysis as the data is publicly available.

Given that the BPS data was the best available source, the choices for the segments were narrowed down to municipal buildings, post-secondary educational institutions, public schools and public hospitals. The municipal buildings did not map well to any segment as defined for this potential study and could not be compared to the DSMSim potential and was, therefore, excluded from further consideration.

The schools segment has been considered in other studies and there was interest from the project team and stakeholder committee to explore an independent analysis with a different segment. The challenge with the university segment was the notable variation in the type of buildings, e.g., libraries, laboratories, classrooms, offices, recreational facilities, and their use and the lack of data to account for such nuances.

Therefore, the hospital segment was finally selected as the segment for analysis as it mapped well to the hospitals segment as defined for this potential study, had less variation in the building types (facilities used for hospitals and for administration) and there was some information available on individual hospitals that could be used to control for other factors that influence consumption.

G.1.2 Econometric Approach to Estimate Achievable Potential

The top-down analysis applies an econometric approach to historical data in order to estimate future energy conservation potential. Specifically, Navigant first utilised a regression analysis and historical hospital data to estimate the historical impact of total cumulative commercial incentives on reduction in energy intensity. The historical impact was then used to estimate conservation potential from the year 2019 through 2038 based on the forecast incentives used in the model.

Navigant investigated two models, a basic and enhanced model, which differ by the inclusion of a variable that accounts for hospital activity. The regression model equations are described below. Navigant also explored incorporating the other hospital indicators obtained from the CIHI dataset, namely administration costs, number of patients readmitted and average cost of stay. The total emergency wait time performed the best and adding more than one indicator variable resulted in spurious correlations makings the results difficult to interpret.

$$\text{Basic: } EI_{i,t} = \alpha_i + \beta_1 HDH_{i,t} + \beta_2 CDH_{i,t} + \beta_3 Price_{i,t} + \beta_4 Incentives_{i,t} + \epsilon_{i,t}$$

$$\text{Enhanced: } EI_{i,t} = \alpha_i + \beta_1 HDH_{i,t} + \beta_2 CDH_{i,t} + \beta_3 Price_{i,t} + \beta_4 Incentives_{i,t} + \beta_5 TotalEmergTime_{i,t} + \epsilon_{i,t}$$

Where:

$EI_{i,t}$ = Energy Intensity for building *i* in year *t*, in [kWh / ft^2] for Electricity and [m^3 / ft^2] for Natural Gas

α_i = A fixed effect for building *i* that captures building specific effects that do not change over time

$HDH_{i,t}$ = Total heating degree hours (base 18°C) experience by building *i* in year *t* within its corresponding IESO zone

$CDH_{i,t}$ = Total cooling degree hours (base 21°C) experience by building *i* in year *t* within its corresponding IESO zone

$Price_{i,t}$ = Retail price of energy for building *i* within its corresponding IESO zone, in [$ / MWh] for Electricity and [¢ / m^3] for Natural Gas

$Incentives_{i,t}$ = Cumulative commercial energy efficiency incentives paid out in year t

$TotalEmergTime_{i,t}$ = Total emergency wait times for hospital *i* in year *t*, used as a measure of hospital activity

$\beta_1, \beta_2, \ldots, \beta_5$ = Parameters of the regression equation, which are the estimated relationship between the variable to which it is attached and the dependent variable

$\epsilon_{i,t}$ = Cluster robust error

The parameter β_4 represents the relationship between total commercial incentives spent and change in energy intensity. After estimating the parameters of the regression model using historical data, this parameter was multiplied by forecast floor space and cumulative commercial incentives to estimate energy conservation potential for each year from 2019 through 2038.

G.1.3 Benchmarking Analysis for Technical and Economic Potential

In order to estimate a historical relationship using an econometric approach, actual data is required on what the consumption would have been if technical and economic potential respectively would have been achieved. This data is not available, and it is not feasible to estimate a counterfactual consumption. Therefore, a benchmarking analysis was undertaken for the selected segment, hospitals, to check against the model's potentials.

The benchmarking analysis estimates the minimum threshold of energy intensity that all buildings would need to achieve in order to deliver the model-estimated technical and economic potential. Specifically, all buildings with an energy intensity currently above this threshold would need to reduce their energy intensity to the threshold, and the change in energy usage associated with this reduction would be equal to the model-estimated potential.

For each type of potential, Navigant determined the benchmarking threshold as the value of energy intensity for which the average change in energy intensity (weighted by floor space) for buildings with energy intensity greater than the threshold is equal to a target value calculated from the energy conservation potential.

Specifically, the benchmarking threshold, $EI_{threshold}$, was calculated as follows:

1. Calculate ΔEI_{target}, the target average change in energy intensity associated with the potential. This value is calculated by dividing the potential number (in units of energy) by the total floor space.
2. Starting with an initial guess for the threshold, $EI_{threshold}$, determine which buildings have an energy intensity greater than the threshold.
3. Calculate $\Delta EI_{threshold}$, the weighted average difference in energy intensity between the current energy intensity of each building and the threshold.
4. Calculate $\epsilon_{threshold}$, the absolute difference between ΔEI_{target} and $\Delta EI_{threshold}$
5. Iterate through steps 2-4 (adjusting the value of $EI_{threshold}$) until $\epsilon_{threshold}$ is minimised (*i.e.*, 0), *i.e.*, ΔEI_{target} is equal to $\Delta EI_{threshold}$

Using the benchmarking threshold determined for technical and economic potential respectively, Navigant calculated the number of buildings that have a current energy intensity greater than the threshold. Based on this, the percentile of buildings that failed the threshold was determined. The difference between the energy intensity threshold and the actual energy intensity multiplied by the floor space summed across all buildings that failed the threshold yields the conservation potential from the model.

For the benchmarking analysis, Navigant removed some buildings from the dataset using criteria aligned with those used by the Ministry of Energy staff that maintain the BPS database. These buildings had reported energy intensity or total consumption that were considered outliers in this context as being too high or too low. Buildings with extreme energy intensity or consumption may be associated with reporting errors or data issues.

Moreover, since these buildings are hospitals, very high energy intensity may be associated with specialised equipment or processes (such as MRIs) that should not be considered as practical targets for energy efficiency. The specific criteria used to identify and remove these outliers for the benchmarking analysis were:

- Energy intensity less than 10 ekWh / sq-ft (electricity and natural gas combined)
- Energy intensity greater than 150 ekWh / sq-ft (electricity and natural gas combined)
- Total consumption less than 100 kWh (electricity) or 5,000 ekWh (natural gas) per year
- Total consumption greater than 20 GWh (electricity) or 20 ekWh (natural gas) per year

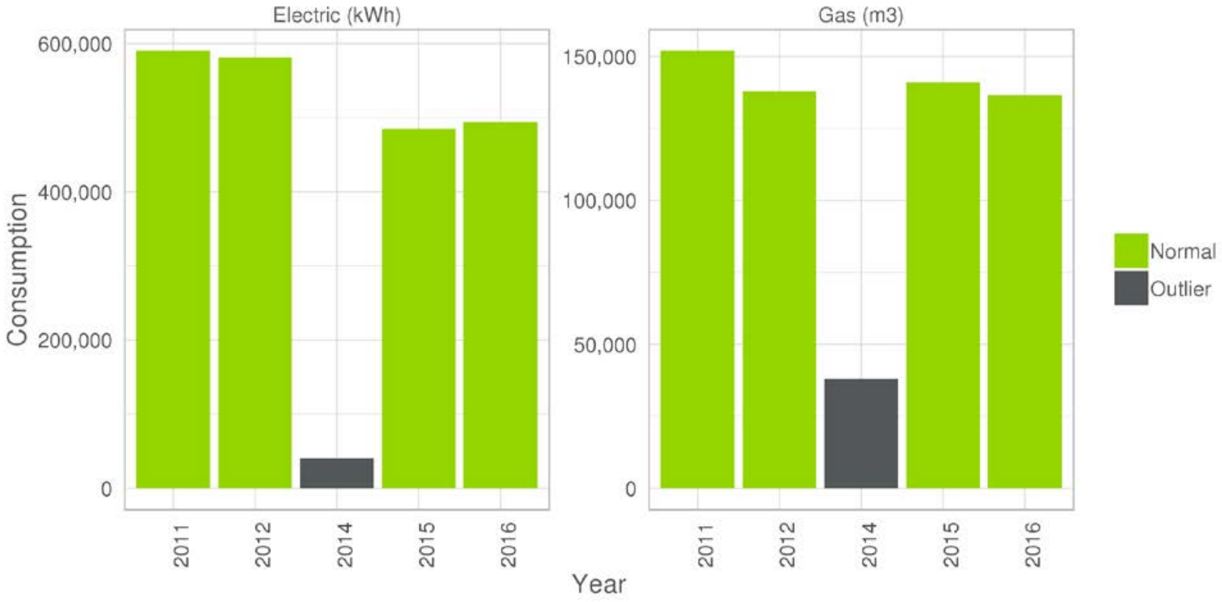
After imposing these restrictions, 78 total buildings were excluded from the benchmarking analysis, or 20% of the sample.

G.1.4 Overview of Data – Additional Detail

BPS Data Outlier Analysis

Navigant inspected the BPS dataset to identify observations for each year that were obviously erroneous, or outliers. For example, Figure G-1 shows two examples of outlier observations in 2014, where consumption of both electricity and natural gas were orders of magnitude lower than every other year in the dataset.

Figure G-1. Examples of Outlier Observations of Consumption



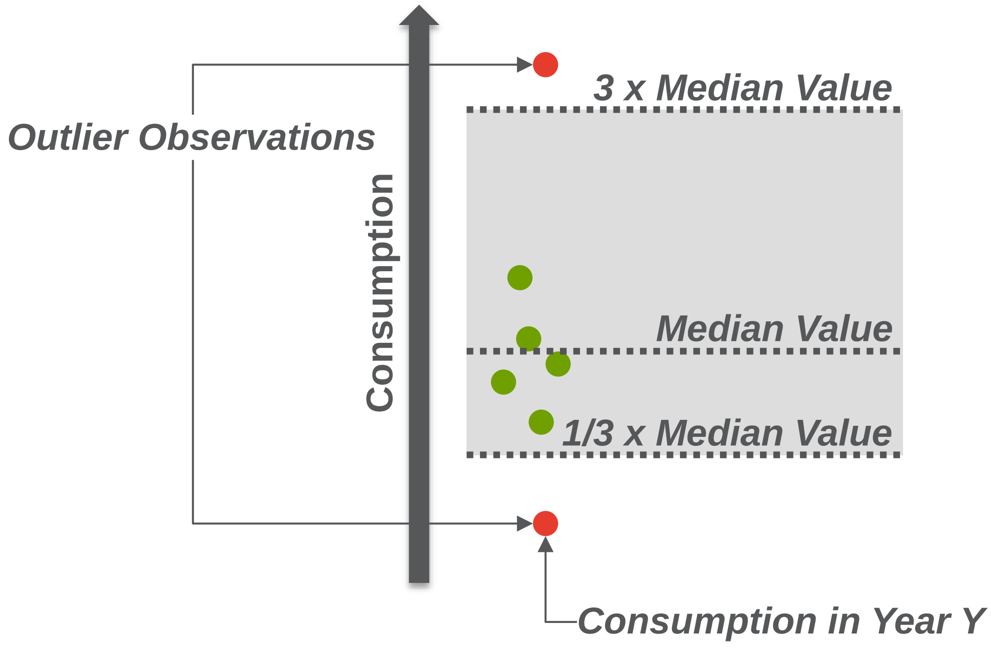
Source: Navigant analysis

Navigant removed these types of outlier observations for each building systematically using the process depicted in Figure G-2. Each building has multiple years of annual electric and gas consumption data, which Navigant analyzed separately. An outlier observation was defined as one that is:

- Greater than 3 times the given building's median value (across all years)
- Less than one-third times the given building's median value (across all years)

Additionally, Navigant removed buildings where observations were only available for 2 years, and the larger consumption value was more than double the smaller value, since Navigant could not determine the accuracy of either value.

Figure G-2. Illustration of Outlier Removal for Each Building



Source: Navigant analysis

Finally, Navigant also performed a similar outlier analysis of floor space for all buildings to remove observations with erroneous floor space information. After all outlier observations were removed, the final dataset included 388 buildings with both electric and gas consumption.

Weather Data Preparation

To capture the effects of weather experienced by each hospital on energy intensity, Navigant prepared annual heating (base 18°C) and cooling (base 21°C) degree hours for each IESO zone for each year from 2011 through 2016 as follows:

1. Select weather stations and collect data: Navigant first selected a group of weather stations by determining the closest weather station to each hospital in the BPS dataset. Navigant then collected hourly weather data from Environment Canada for all days from 2011 through 2016.
2. Inspect data for missing or erroneous values: Navigant inspected each weather station to determine data quality. For some stations, majority of the historical data was missing and therefore could not be used. For other stations, Navigant interpolated between known data points to fill in missing values.
3. Calculate an average temperature profile for each IESO zone: Due to the challenges with some stations being excluded on account of missing most observations, Navigant created an average weather series for each IESO zone in order to ensure an observation in each hour of each day.[107]

---

[107] Due to limited data, Navigant calculated an average temperature series for the Ottawa and East IESO Zones combined, in order to ensure the completeness of the time series.

4. Calculate annual heating and cooling degree hours: Using the average temperature profile for each IESO zone, Navigant calculated annual heating (base 18°C) and cooling (base 21°C) degree hours.

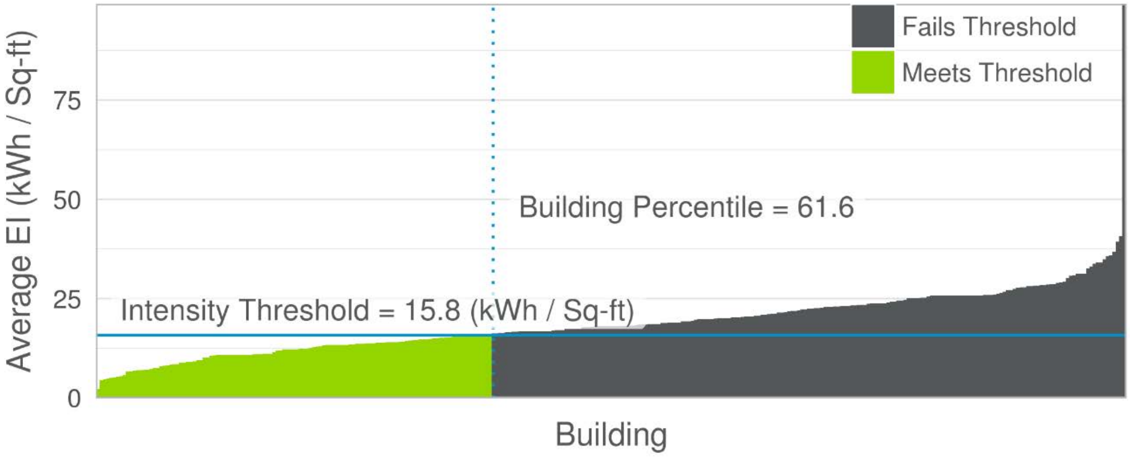
G.2 Results (Expanded)

This section describes the benchmarking results for technical, economic, and achievable potential.

G.2.1 Technical Potential

Figure G-3 shows the results of the electric benchmarking analysis for technical potential. For electricity, technical potential savings of 33.6%, DSMSim potential as a percentage of the reference forecast in 2038, are achieved if 61.6% of BPS buildings reduce their intensity to that of the building at the 38.4th percentile. Technical potential could be achieved if the maximum energy intensity per building was set at 15.8 kWh/sq-ft.

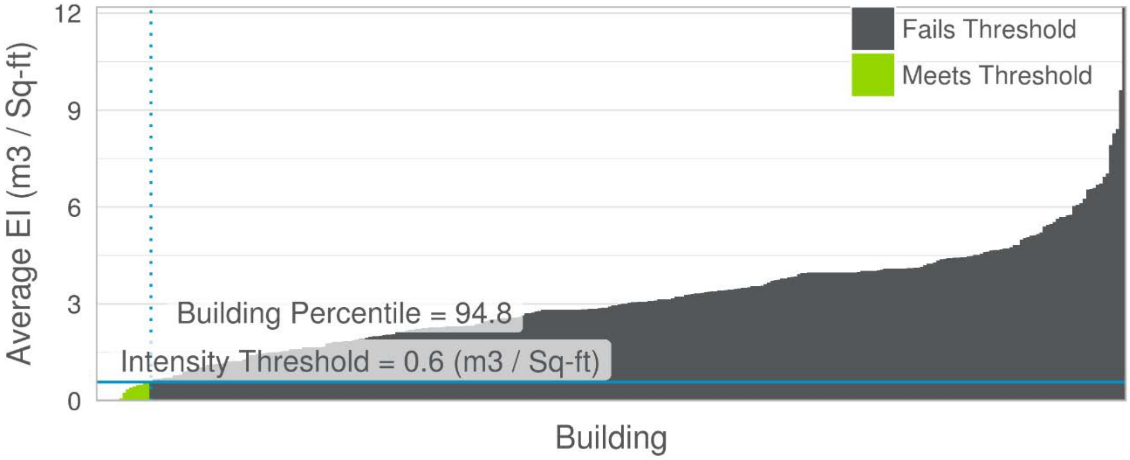
Figure G-3. Technical Potential Benchmarking – Electricity



Source: Navigant analysis

Figure G-4 shows the results of the natural gas benchmarking analysis for technical potential. Technical potential savings of 44.4% are achieved if 94.8% of BPS buildings reduce their intensity to that of the building at the 5.2th percentile. Technical potential could be achieved if the maximum energy intensity per building was set at 0.6 m^3/sq-ft.

Figure G-4. Technical Potential Benchmarking – Natural Gas

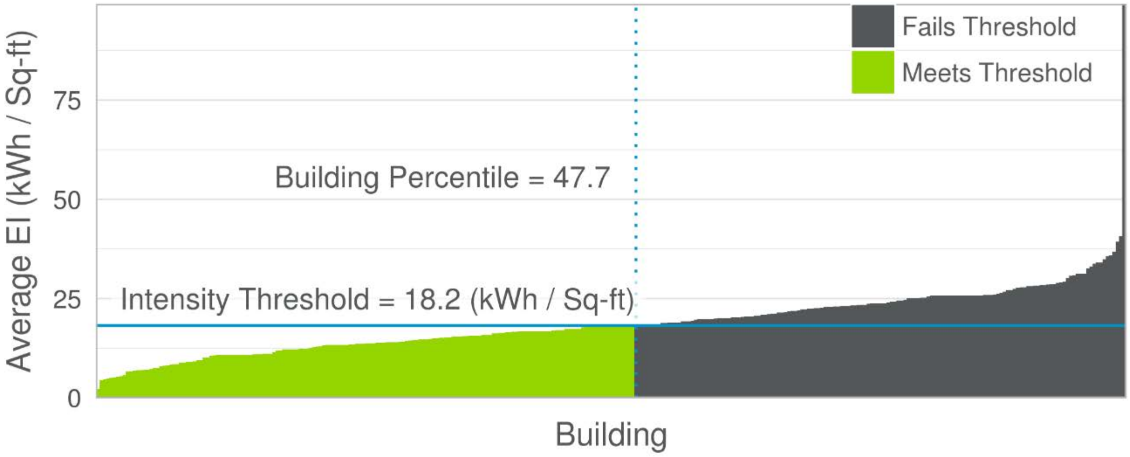


Source: Navigant analysis

G.2.2 Economic Potential

Figure G-5 shows the results of the electric benchmarking analysis for economic potential. For electricity, economic potential savings of 28.5% are achieved if 47.7% of BPS buildings reduce their intensity to that of the building at the 52.3th percentile. Economic potential could be achieved if the maximum energy intensity per building was set at 18.2 kWh/sq-ft.

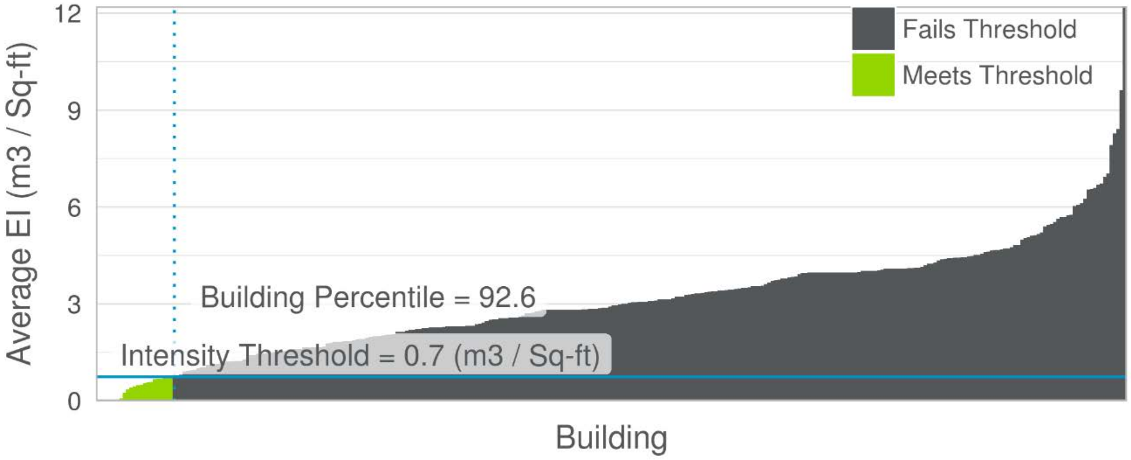
Figure G-5. Economic Potential Benchmarking – Electricity



Source: Navigant analysis

Figure G-6 shows the results of the natural gas benchmarking analysis for economic potential. Economic potential savings of 42.0% are achieved if 92.6% of BPS buildings reduce their intensity to that of the building at the 7.4th percentile. Economic potential could be achieved if the maximum energy intensity per building was set at 0.7 m^3/sq-ft.

Figure G-6. Economic Potential Benchmarking – Natural Gas



Source: Navigant analysis

G.2.3 Achievable Potential

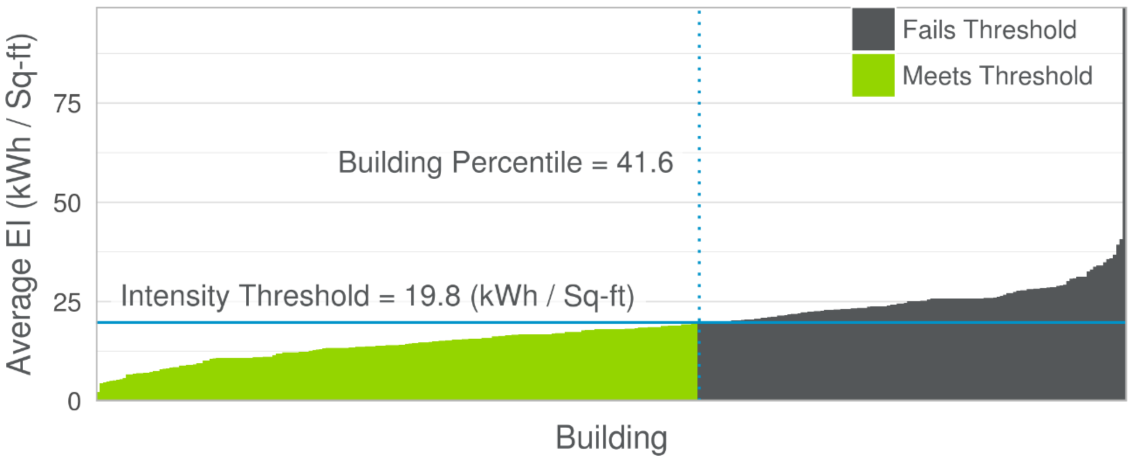
Table G-1 lists the electric benchmarking results for the three achievable potential scenarios. These results are also illustrated in Figure G-7 through Figure G-9. For example, Scenario A potential savings of 21% are achieved if 41.6% of BPS buildings reduce their intensity to that of the building at the 58.4th percentile. Achievable potential could be achieved if the maximum energy intensity per building was set at 19.8 kWh/sq-ft.

Table G-1. Achievable Potential Benchmarking Results – Electricity

Scenario	Potential Savings	Percentage of Buildings Above Threshold	Percentile of Maximum Energy Intensity	Maximum Energy Intensity per Building (kWh / Sq-ft)
Scenario A	21.8%	41.6%	58.4	19.8
Scenario B	26.6%	42.3%	57.7	19.3
Scenario C	22.1%	41.6%	58.4	19.8

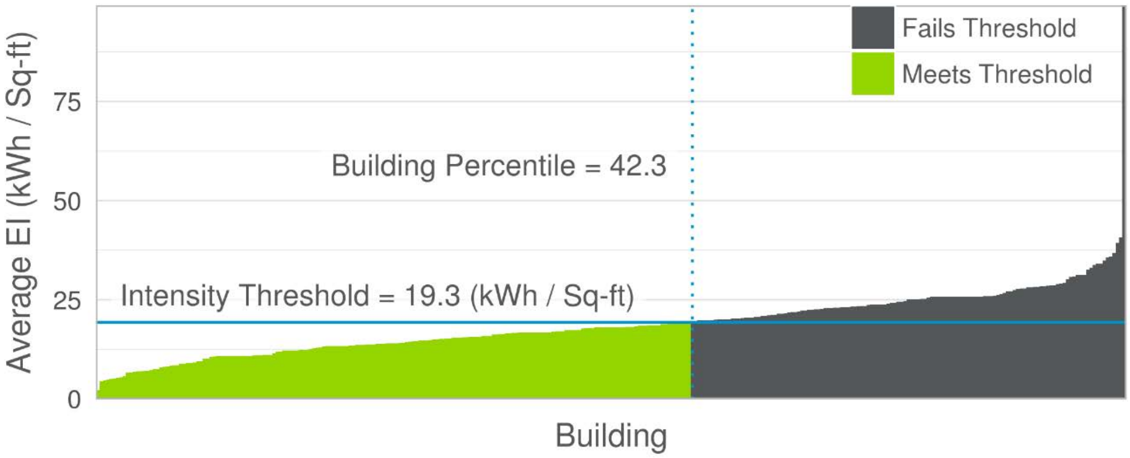
Source: Navigant analysis

Figure G-7. Scenario A Potential Benchmarking – Electricity



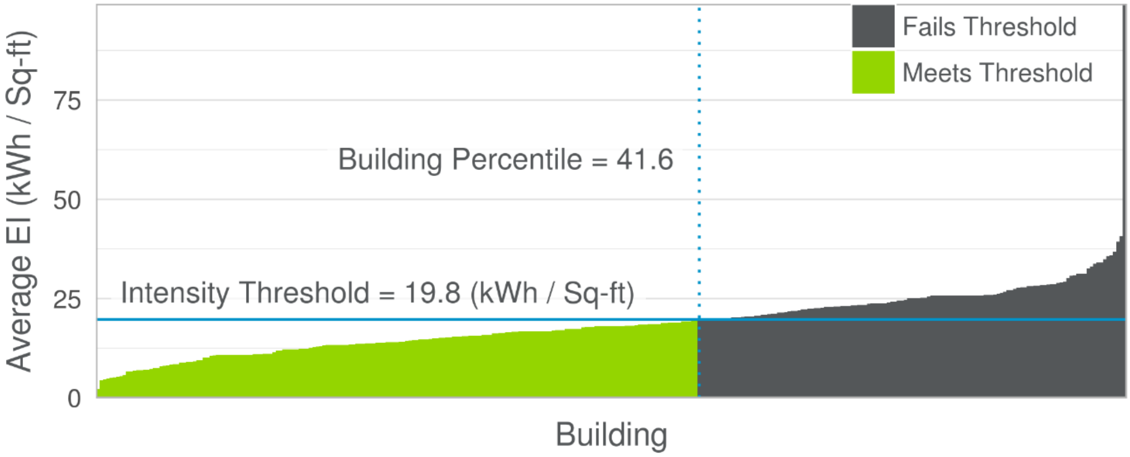
Source: Navigant analysis

Figure G-8. Scenario B Potential Benchmarking – Electricity



Source: Navigant analysis

Figure G-9. Scenario C Potential Benchmarking – Electricity



Source: Navigant analysis

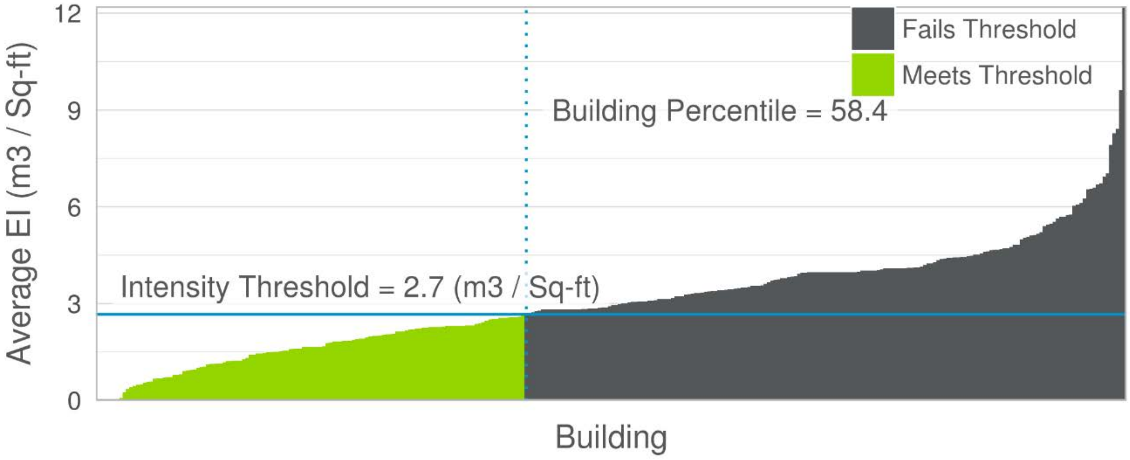
Table G-2 lists the natural gas benchmarking results for the three achievable potential scenarios. These results are also illustrated in Figure G-10 through Figure G-12. For example, Scenario A potential savings of 21% are achieved if 58.4% of BPS buildings reduce their intensity to that of the building at the 41.6th percentile. Achievable potential could be achieved if the maximum energy intensity per building was set at 2.7 m^3/sq-ft.

Table G-2. Achievable Potential Benchmarking Results – Natural Gas

Scenario	Potential Savings	Percentage of Failing Buildings	Percentile of Maximum Energy Intensity	Maximum Energy Intensity per Building (m^3 / sq-ft)
Scenario A	21.3%	58.4%	41.6	2.7
Scenario B	36.4%	88.7%	11.3	1.1
Scenario C	25.9%	75.2%	24.8	1.9

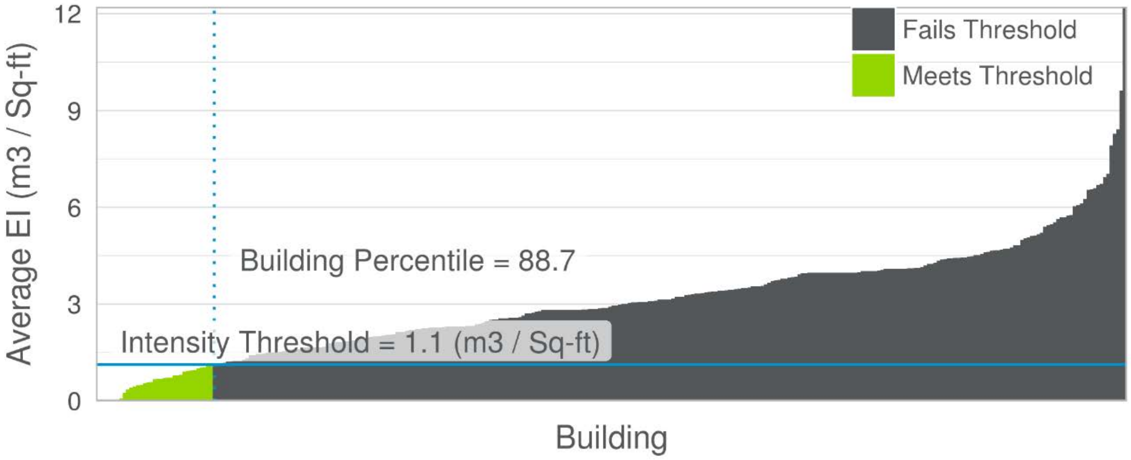
Source: Navigant analysis

Figure G-10. Scenario A Potential Benchmarking – Natural Gas



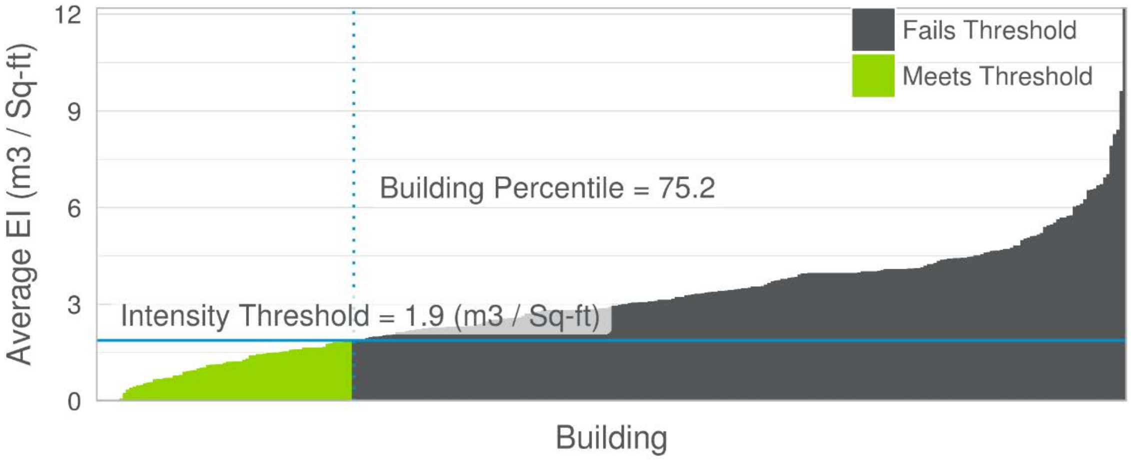
Source: Navigant analysis

Figure G-11. Scenario B Potential Benchmarking – Natural Gas



Source: Navigant analysis

Figure G-12. Scenario C Potential Benchmarking – Natural Gas



Source: Navigant analysis

Appendix H. COMPARISON WITH OTHER JURISDICTIONS

This appendix provides a table highlighting the projected conservation potential estimated in a number of other jurisdictions for natural gas and electricity, for a variety of different types of potential (technical, economic, etc.). This table provides the study terminal year estimate of potential, as a fraction of projected consumption, by sector. In many cases, these reports included some, but not all, of the types of potential of interest. For example: in the case of New Jersey, only economic and maximum achievable potential values are presented. Where no estimate was available in the published report, the potential value is presented as NA.

Navigant's key criteria for including studies in this table were that, for inclusion a study must be:

- Less than 10 years old;
- Cover a period of analysis of at least 10 years; and,
- Be publicly available (i.e., published online).

Great caution should be used in comparing these results to those reported as part of this study. It is generally inappropriate to compare any single study to any other single study – there are too many complexities, too many regional variations, and too many different policy priorities at play to reasonably compare any two studies with one another. That said, Navigant believes that with a sufficiently large sample (such as that presented below) a review of the findings in other jurisdictions can provide valuable context when reviewing the findings for Ontario.

The other studies presented below are sorted firstly by fuel (electricity, then natural gas), and then by sector (residential, commercial, and industrial).

Sector	Fuel	Year	Prepared For	Author	Jurisdiction	Reference Forecast Period	Annual Savings From Cumulative Adoption, Terminal Year of Study					Average Incremental Annual Savings				
							Technical	Economic	Achievable (Low)	Achievable (Med)	Achievable (High)	Technical	Economic	Achievable (Low)	Achievable (Med)	Achievable (High)
Residential	**Electricity**	**2019**	**IESO and OEB**	**Navigant**	**Ontario**	**2019 - 2038**	**30%**	**20%**	**9%**	**11%**	**13%**	**1.5%**	**1.0%**	**0.5%**	**0.5%**	**0.6%**
Residential	Electricity	2016	IESO	Nexant	Ontario	2015 - 2035	73%	38%	5%	5%	6%	3.5%	1.8%	0.3%	0.3%	0.3%
Residential	Electricity	2014	Indianapolis Power and Light Company	AEG	Indiana	2018 - 2034	27%	13%	NA	8%	NA	1.6%	0.8%	NA	0.4%	NA
Residential	Electricity	2014	Vermont Public Service Department	GDS Associates	Vermont	2014 - 2033	40%	37%	NA	NA	29%	2.0%	1.9%	NA	NA	1.5%
Residential	Electricity	2015	Dominion Virginia Power	KEMA	Virginia	2014 - 2023	49%	24%	NA	5%	8%	4.9%	2.4%	NA	0.5%	0.8%
Residential	Electricity	2015	Pennsylvania Public Utility Commission	Nexant / GDS Associates	Pennsylvania I	2016 - 2025	40%	25%	13%	13%	18%	4.0%	2.5%	1.3%	1.3%	1.8%
Residential	Electricity	2016	Ameren Illinois	AEG	Illinois I	2017 - 2036	19%	11%	NA	5%	6%	1.0%	0.5%	NA	0.2%	0.3%
Residential	Electricity	2016	Idaho Power Company	AEG	Idaho	2017 - 2036	11%	8%	NA	8%	NA	0.6%	0.4%	NA	0.4%	NA
Residential	Electricity	2016	Ameren Illinois	AEG	Illinois I	2017 - 2036	19%	11%	NA	5%	6%	1.0%	0.5%	NA	0.2%	0.3%
Residential	Electricity	2017	Public Service Commission of Wisconsin	Cadmus	Wisconsin	2019 - 2030	46%	37%	12%	17%	19%	3.8%	3.1%	1.0%	1.4%	1.5%
Residential	Electricity	2017	Louisville Gas and Electric Company	Cadmus	Kentucky	2019 - 2038	36%	10%	4%	6%	6%	1.8%	0.5%	0.2%	0.3%	0.3%
Residential	Electricity	2017	Michigan Public Service Commission	GDS Associates	Michigan	2017 - 2036	42%	36%	NA	20%	NA	2.1%	1.8%	NA	1.0%	NA
Residential	Electricity	2017	Puget Sound Energy	Navigant	Washington	2017 - 2037	28%	NA	NA	NA	NA	1.3%	NA	NA	NA	NA
Residential	Electricity	2017	Iowa Utility Association	Dunsky/Michaels Energy/Opinion Dynamics	Iowa	2018 - 2027	31%	24%	15%	15%	18%	3.1%	2.4%	1.5%	1.5%	1.8%
Residential	Electricity	2018	Energy Efficiency Alberta	Navigant	Alberta	2019 - 2038	NA	NA	NA	9%	NA	NA	NA	NA	0.5%	NA
Residential	Electricity	2019	New Jersey Board of Public Utilities	Optimal Energy	New Jersey	2020 - 2029	NA	23%	NA	NA	13%	NA	2.3%	NA	NA	1.3%
Commercial	**Electricity**	**2019**	**IESO and OEB**	**Navigant**	**Ontario**	**2019 - 2038**	**30%**	**23%**	**18%**	**19%**	**22%**	**1.5%**	**1.2%**	**0.9%**	**0.9%**	**1.1%**
Commercial	Electricity	2016	IESO	Nexant	Ontario	2015 - 2035	65%	38%	21%	21%	33%	3.1%	1.8%	1.0%	1.0%	1.6%

Sector	Fuel	Year	Prepared For	Author	Jurisdiction	Reference Forecast Period	Annual Savings From Cumulative Adoption, Terminal Year of Study					Average Incremental Annual Savings				
							Technical	Economic	Achievable (Low)	Achievable (Med)	Achievable (High)	Technical	Economic	Achievable (Low)	Achievable (Med)	Achievable (High)
Commercial	Electricity	2014	Indianapolis Power and Light Company	AEG	Indiana	2018 - 2034	43%	38%	NA	15%	NA	2.6%	2.2%	NA	0.9%	NA
Commercial	Electricity	2014	Vermont Public Service Department	GDS Associates	Vermont	2014 - 2033	22%	21%	NA	NA	19%	1.1%	1.0%	NA	NA	0.9%
Commercial	Electricity	2015	Pennsylvania Public Utility Commission	Nexant / GDS Associates	Pennsylvania I	2016 - 2025	23%	13%	6%	6%	11%	2.3%	1.3%	0.6%	0.6%	1.1%
Commercial	Electricity	2015	Dominion Virginia Power	KEMA	Virginia	2014 - 2023	30%	20%	NA	2%	4%	3.0%	2.0%	NA	0.2%	0.4%
Commercial	Electricity	2016	Idaho Power Company	AEG	Idaho	2017 - 2036	31%	20%	NA	16%	NA	1.5%	1.0%	NA	0.8%	NA
Commercial	Electricity	2017	Public Service Commission of Wisconsin	Cadmus	Wisconsin	2019 - 2030	17%	17%	9%	12%	14%	1.4%	1.4%	0.7%	1.0%	1.1%
Commercial	Electricity	2017	Puget Sound Energy	Navigant	Washington	2017 - 2037	25%	NA	NA	NA	NA	1.2%	NA	NA	NA	NA
Commercial	Electricity	2017	Louisville Gas and Electric Company	Cadmus	Kentucky	2019 - 2038	29%	9%	4%	6%	7%	1.5%	0.5%	0.2%	0.3%	0.3%
Commercial	Electricity	2017	Michigan Public Service Commission	GDS Associates	Michigan	2017 - 2036	44%	38%	NA	24%	NA	2.2%	1.9%	NA	1.2%	NA
Commercial	Electricity	2017	Iowa Utility Association	Dunsky/Michaels Energy/Opinion Dynamics	Iowa	2018 - 2027	32%	28%	13%	13%	22%	3.2%	2.8%	1.3%	1.3%	2.2%
Commercial	Electricity	2018	Energy Efficiency Alberta	Navigant	Alberta	2019 - 2038	NA	NA	NA	19%	NA	NA	NA	NA	1.0%	NA
Commercial	Electricity	2019	New Jersey Board of Public Utilities	Optimal Energy	New Jersey	2020 - 2029	NA	42%	NA	NA	27%	NA	4.2%	NA	NA	2.7%
Industrial	**Electricity**	**2019**	**IESO and OEB**	**Navigant**	**Ontario**	**2019 - 2038**	**14%**	**13%**	**7%**	**8%**	**10%**	**0.7%**	**0.6%**	**0.3%**	**0.4%**	**0.5%**
Industrial	Electricity	2016	IESO	Nexant	Ontario	2015 - 2035	17%	13%	4%	4%	10%	0.8%	0.6%	0.2%	0.2%	0.5%
Industrial	Electricity	2014	Indianapolis Power and Light Company	AEG	Indiana	2018 - 2034	25%	24%	NA	8%	NA	1.5%	1.4%	NA	0.5%	NA
Industrial	Electricity	2015	Pennsylvania Public Utility Commission	Nexant / GDS Associates	Pennsylvania I	2016 - 2025	21%	17%	6%	6%	11%	2.1%	1.7%	0.6%	0.6%	1.1%
Industrial	Electricity	2016	Ameren Illinois	AEG	Illinois I	2017 - 2036	21%	15%	NA	10%	12%	1.0%	0.8%	NA	0.5%	0.6%
Industrial	Electricity	2016	Idaho Power Company	AEG	Idaho	2017 - 2036	23%	19%	NA	16%	NA	1.1%	0.9%	NA	0.8%	NA

Sector	Fuel	Year	Prepared For	Author	Jurisdiction	Reference Forecast Period	Annual Savings From Cumulative Adoption, Terminal Year of Study					Average Incremental Annual Savings				
							Technical	Economic	Achievable (Low)	Achievable (Med)	Achievable (High)	Technical	Economic	Achievable (Low)	Achievable (Med)	Achievable (High)
Industrial	Electricity	2016	Louisville Gas and Electric Company	Cadmus	Kentucky	2016 - 2035	15%	14%	NA	NA	NA	0.8%	0.7%	NA	NA	NA
Industrial	Electricity	2017	Public Service Commission of Wisconsin	Cadmus	Wisconsin	2019 - 2030	15%	13%	7%	10%	11%	1.2%	1.1%	0.6%	0.8%	0.9%
Industrial	Electricity	2017	Puget Sound Energy	Navigant	Washington	2017 - 2037	19%	NA	NA	NA	NA	0.9%	NA	NA	NA	NA
Industrial	Electricity	2017	Michigan Public Service Commission	GDS Associates	Michigan	2017 - 2036	31%	27%	NA	16%	NA	1.5%	1.3%	NA	0.8%	NA
Industrial	Electricity	2017	Iowa Utility Association	Dunsky/Michaels Energy/Opinion Dynamics	Iowa	2018 - 2027	17%	15%	8%	8%	13%	1.7%	1.5%	0.8%	0.8%	1.3%
Industrial	Electricity	2018	Energy Efficiency Alberta	Navigant	Alberta	2019 - 2038	NA	NA	NA	10%	NA	NA	NA	NA	0.5%	NA
Residential	**Gas**	**2019**	**IESO and OEB**	**Navigant**	**Ontario**	**2019 - 2038**	**35%**	**22%**	**7%**	**9%**	**16%**	**1.7%**	**1.1%**	**0.3%**	**0.5%**	**0.8%**
Residential	Gas	2016	OEB	ICF	Ontario	2014 - 2030	65%	27%	9%	9%	18%	3.8%	1.6%	0.5%	0.5%	1.0%
Residential	Gas	2015	Enbridge Gas Distribution	Navigant	Ontario	2014 - 2024	47%	19%	NA	4%	NA	4.3%	1.7%	NA	0.3%	NA
Residential	Gas	2011	Union Gas Distribution	ICF	Ontario	2007 - 2017	NA	18%	NA	11%	11%	NA	1.7%	NA	1.0%	1.0%
Residential	Gas	2016	Ameren Illinois	AEG	Illinois I	2017 - 2036	16%	8%	NA	5%	11%	0.8%	0.4%	NA	0.2%	0.5%
Residential	Gas	2017	Puget Sound Energy	Navigant	Washington	2017 - 2037	19%	NA	NA	NA	NA	0.9%	NA	NA	NA	NA
Residential	Gas	2017	Louisville Gas and Electric Company	Cadmus	Kentucky	2019 - 2038	49%	35%	4%	7%	8%	2.5%	1.8%	0.2%	0.3%	0.4%
Residential	Gas	2017	Iowa Utility Association	Dunsky/Michaels Energy/Opinion Dynamics	Iowa	2018 - 2027	27%	20%	10%	10%	16%	2.7%	2.0%	1.0%	1.0%	1.6%
Residential	Gas	2018	Energy Efficiency Alberta	Navigant	Alberta	2019 - 2038	NA	NA	NA	6%	NA	NA	NA	NA	0.3%	NA
Residential	Gas	2011	FortisBC	ICF	BC	2010 - 2030	NA	9%	NA	5%	8%	NA	0.4%	NA	0.2%	0.4%
Residential	Gas	2016	FortisBC	Navigant	BC	2016 - 2035	32%	30%	NA	11%	NA	1.6%	1.5%	NA	0.5%	NA
Commercial	**Gas**	**2019**	**IESO and OEB**	**Navigant**	**Ontario**	**2019 - 2038**	**41%**	**38%**	**20%**	**22%**	**32%**	**2.0%**	**1.9%**	**1.0%**	**1.1%**	**1.6%**

Sector	Fuel	Year	Prepared For	Author	Jurisdiction	Reference Forecast Period	Annual Savings From Cumulative Adoption, Terminal Year of Study					Average Incremental Annual Savings				
							Technical	Economic	Achievable (Low)	Achievable (Med)	Achievable (High)	Technical	Economic	Achievable (Low)	Achievable (Med)	Achievable (High)
Commercial	Gas	2016	OEB	ICF	Ontario	2014 - 2030	52%	32%	6%	6%	18%	3.1%	1.9%	0.3%	0.3%	1.1%
Commercial	Gas	2015	Enbridge Gas Distribution	Navigant	Ontario	2014 - 2024	27%	26%	NA	8%	NA	2.5%	2.4%	NA	0.7%	NA
Commercial	Gas	2011	Union Gas Distribution	ICF	Ontario	2007 - 2017	NA	30%	NA	7%	13%	NA	2.7%	NA	0.6%	1.2%
Commercial	Gas	2016	Ameren Illinois	AEG	Illinois I	2017 - 2036	13%	6%	NA	3%	9%	0.7%	0.3%	NA	0.2%	0.5%
Commercial	Gas	2017	Puget Sound Energy	Navigant	Washington	2017 - 2037	23%	NA	NA	NA	NA	1.1%	NA	NA	NA	NA
Commercial	Gas	2017	Louisville Gas and Electric Company	Cadmus	Kentucky	2019 - 2038	34%	32%	3%	5%	6%	1.7%	1.6%	0.1%	0.3%	0.3%
Commercial	Gas	2017	Iowa Utility Association	Dunsky/Michaels Energy/Opinion Dynamics	Iowa	2018 - 2027	23%	19%	9%	9%	15%	2.3%	1.9%	0.9%	0.9%	1.5%
Commercial	Gas	2018	Energy Efficiency Alberta	Navigant	Alberta	2019 - 2038	NA	NA	NA	6%	NA	NA	NA	NA	0.3%	NA
Commercial	Gas	2011	FortisBC	ICF	BC	2010 - 2030	NA	21%	NA	8%	11%	NA	1.0%	NA	0.4%	0.5%
Commercial	Gas	2016	FortisBC	Navigant	BC	2016 - 2035	28%	23%	NA	14%	NA	1.4%	1.2%	NA	0.7%	NA
Industrial	**Gas**	**2019**	**IESO and OEB**	**Navigant**	**Ontario**	**2019 - 2038**	**23%**	**22%**	**8%**	**13%**	**19%**	**1.1%**	**1.1%**	**0.4%**	**0.7%**	**0.9%**
Industrial	Gas	2016	OEB	ICF	Ontario	2014 - 2030	25%	24%	12%	12%	19%	1.4%	1.4%	0.7%	0.7%	1.1%
Industrial	Gas	2015	Enbridge Gas Distribution	Navigant	Ontario	2014 - 2024	38%	36%	NA	15%	NA	3.5%	3.3%	NA	1.3%	NA
Industrial	Gas	2011	Union Gas Distribution	ICF	Ontario	2007 - 2017	NA	34%	NA	8%	15%	NA	3.1%	NA	0.7%	1.4%
Industrial	Gas	2016	Ameren Illinois	AEG	Illinois I	2017 - 2036	12%	7%	NA	4%	11%	0.6%	0.4%	NA	0.2%	0.6%
Industrial	Gas	2016	Louisville Gas and Electric Company	Cadmus	Kentucky	2016 - 2035	13%	13%	NA	NA	NA	0.6%	0.6%	NA	NA	NA
Industrial	Gas	2017	Puget Sound Energy	Navigant	Washington	2017 - 2037	29%	NA	NA	NA	NA	1.4%	NA	NA	NA	NA
Industrial	Gas	2017	Iowa Utility Association	Dunsky/Michaels Energy/Opinion Dynamics	Iowa	2018 - 2027	15%	13%	7%	7%	10%	1.5%	1.3%	0.7%	0.7%	1.0%

Sector	Fuel	Year	Prepared For	Author	Jurisdiction	Reference Forecast Period	Annual Savings From Cumulative Adoption, Terminal Year of Study					Average Incremental Annual Savings				
							Technical	Economic	Achievable (Low)	Achievable (Med)	Achievable (High)	Technical	Economic	Achievable (Low)	Achievable (Med)	Achievable (High)
Industrial	Gas	2018	Energy Efficiency Alberta	Navigant	Alberta	2019 - 2038	NA	NA	NA	6%	NA	NA	NA	NA	0.3%	NA
Industrial	Gas	2011	FortisBC	ICF	BC	2010 - 2030	NA	12%	NA	7%	10%	NA	0.6%	NA	0.3%	0.5%
Industrial	Gas	2016	FortisBC	Navigant	BC	2016 - 2035	21%	20%	NA	13%	NA	1.1%	1.0%	NA	0.6%	NA