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Final Report

Natural Gas Conservation Potential Study

June 30, 2016, updated on July 7, 2016

Submitted to:

Ontario Energy Board

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Executive Summary

Background and Objectives

Charged with regulating Ontario's natural gas and electricity sectors, the Ontario Energy Board (OEB) was directed by the Minister of Energy to have an achievable potential study completed for natural gas efficiency in Ontario.

The objective of this study is to estimate the achievable potential for natural gas efficiency in Ontario from 2015 to 2030, in order to:

- Inform natural gas Demand Side Management (DSM) program design and delivery at the mid-term review of the 2015-2020 DSM Framework
- Provide guidance to utilities for DSM program design and delivery beyond 2020
- Support the assessment of the role that DSM may serve in future distribution infrastructure planning processes at the regional and local levels

The scope of this work includes the planning and execution of an achievable potential study in the franchise areas of Union Gas Limited ("Union Gas") and Enbridge Gas Distribution Inc. ("Enbridge Gas Distribution") collectively referred to as the "utilities". This study builds on the past natural gas utility achievable potential work as well as the OEB's 2015-2020 DSM Framework, the 2015-2020 DSM plans prepared by Union Gas and Enbridge Gas Distribution, annual reports of the utilities to the OEB, the 2015-2020 DSM Decision, DSM program evaluations, and other studies on DSM market characterization and technology assessments. This study also leverages input from the DSM Technical Working Group (TWG), which included experts proposed by stakeholders and representatives from the utilities, Independent Electricity System Operator, Ministry of Energy, and Environmental Commissioner of Ontario.

Given the emergence of the cap and trade initiative since the study was initiated, the carbon impacts were not included in the avoided costs analysis. It was determined that it would be prudent to defer consideration of the issue until final details related to the cap and trade initiative are available to inform the analysis. Instead, a sensitivity analysis has been undertaken to provide a preliminary assessment of what will be the impact of higher avoided costs on the economic potential.

Scope

The scope of this study is summarized below:

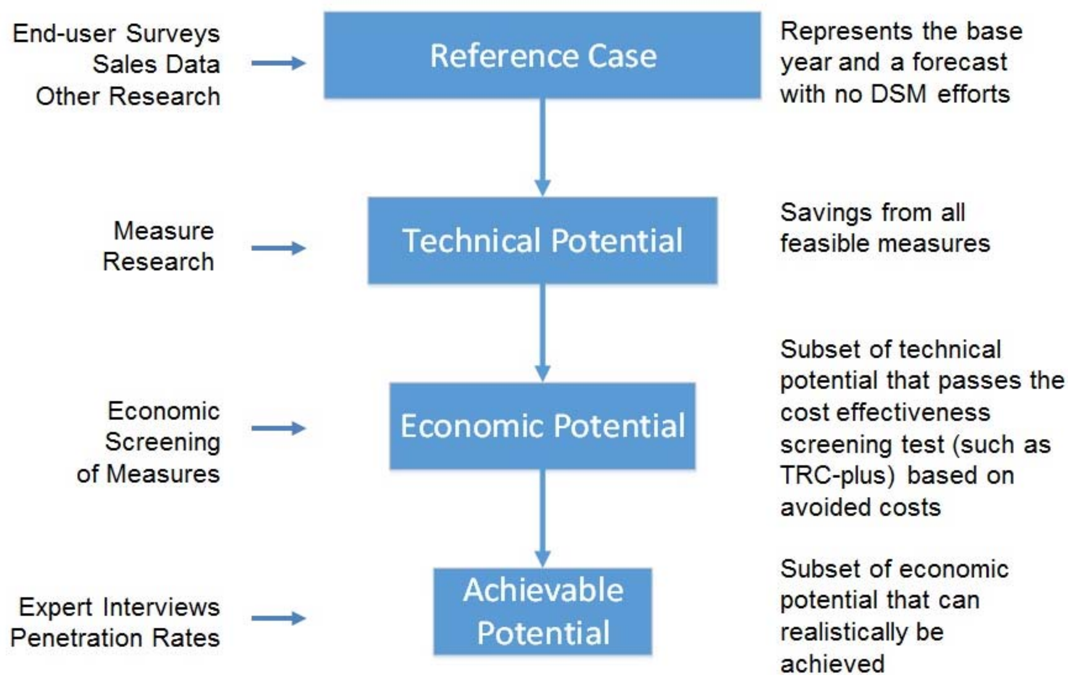
- **Sector Coverage:** The study addresses three sectors: residential, commercial[1], and industrial.
- **Geographical Coverage**: The study results are presented for the total Union Gas and Enbridge Gas Distribution franchise areas.
- **Study Period**: This study covers a 17-year period from 2014 to 2030. The base year for the study is the calendar year 2014. The base year was calibrated to the 2014 actual sales data provided by the gas utilities.
- **Measures:** The study addresses the full range of natural gas energy efficiency technologies, and operation, maintenance and control measures.

[1] Throughout this report the term "commercial" also includes institutional sectors, such as schools, hospitals, etc., unless otherwise noted.

Methodology

The study generally followed a traditional approach in determining the natural gas conservation potential in Ontario, as shown in Exhibit ES 1.

Exhibit ES 1 General methodology for potential studies



A reference case was first developed to represent the base year and a forecast that did not include any DSM efforts.[2] Next, three conservation potential scenarios were developed: the technical potential scenario (includes savings from all technically-feasible measures), the economic potential scenario (a subset of the technical potential that includes only those measures that are cost-effective using the TRC-plus[3] test) and finally, the achievable potential scenario. The achievable potential scenario is the subset of the economic potential savings that can realistically be achieved. Three achievable potential scenarios were analyzed: unconstrained (assumes no budget constraints or policy restrictions), semi-constrained (budgets were initially set at the levels approved by the OEB for 2015-2017, then gradually increased so they doubled by 2020 and remained at that level until 2030), and constrained (budgets from 2015-2020 are the OEB-approved budget levels and remain at 2020 level through 2030). In order to determine the achievable potential, ICF interviewed experts in the field of energy efficiency in the residential, commercial, and industrial sectors and developed adoption curves for all measures included in the analysis. More details on the methodology can be found in chapter 2.

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[2] Please note that the reference case does not account for initiatives related to the Climate Change Action Plan, which was under development at the time the analysis was completed. It is anticipated that some of these initiatives would reduce gas consumption in the reference case forecast, which would reduce the achievable potential savings found in this study.

[3] The TRC-plus test is a benefit/cost ratio comparing benefits and cost of energy efficiency investments, and includes a 15% adder that accounts for the non-energy benefits associated with DSM programs, such as environmental, economic, and social benefits, as selected by the OEB in 2015-2020 DSM Framework. It is aligned with the cost effectiveness test used by the IESO, as per the Minister of Energy's Conservation First Framework. Please refer to the glossary for a full definition of TRC-plus.

Measures and Input Assumptions

The study considered technologies and operation, maintenance and control measures that save natural gas across energy end-uses in each sector. In total 52 measures were considered in the residential sector, 59 measures in the commercial sector, and 57 measures in the industrial sector. More details on the measures and input assumptions can be found in chapter 2.

As in any study of this type, the results presented in this report are based on a number of additional important assumptions. Those assumptions include the current penetration of measures and the rate of future growth in the building stock. Wherever possible, the assumptions used in this study are consistent with those used by the OEB and the utilities. As such, the reader should use the results presented in this report as best available estimates; major assumptions, information sources, and caveats are noted throughout the report.

Avoided Costs

Avoided costs are one of the key components of the cost-effectiveness tests that are used to evaluate energy efficiency investments. The natural gas avoided costs used in this study include direct natural gas supply and infrastructure costs that can be avoided by the utilities as a result of a decrease in demand. The avoided cost analysis includes three main components: natural gas commodity costs which represent about 75% of total avoided costs; upstream capacity costs (pipeline and storage costs upstream of the utility citygate) which represents about 17% of total avoided costs; and, downstream distribution system costs (transmission, storage and distribution system downstream of the utility citygate) which represents about 8% of total avoided costs. A detailed description of the avoided costs is provided in chapter 3.

Overall Study Findings

The study findings confirm the existence of significant cost-effective opportunities for natural gas savings in Ontario. Exhibit ES 2 and Exhibit ES 3 show the reference case and the savings associated with the various conservation potential scenarios discussed above. Exhibit ES 4 presents a summary of the total achievable potential savings and program costs for all three sectors for each achievable potential scenario in 2020 and in 2030.

Exhibit ES 2 Total Reference, Technical, Economic and Achievable Potential Annual Natural Gas Consumption

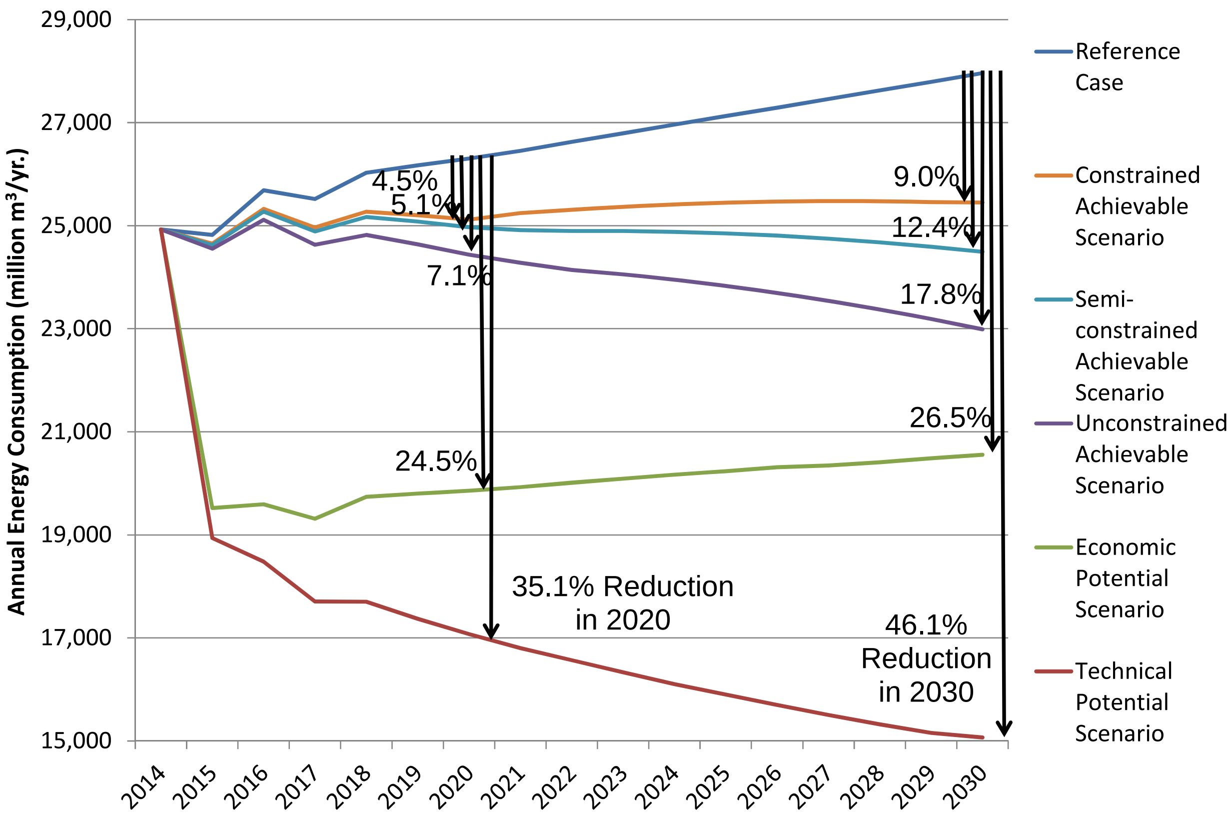


Exhibit ES 3 Total Technical, Economic, and Achievable Potential Annual Savings Relative to Reference Case

Year	Reference Case Use (million m^3/yr.)	Technical Potential		Economic Potential		Unconstrained Achievable Potential		Semi-constrained Achievable Potential		Constrained Achievable Potential	
		Absolute Savings (million m^3/yr.)	Savings Relative to Reference Case (%)	Absolute Savings (million m^3/yr.)	Relative to Reference Case (%)	Absolute Savings (million m^3/yr.)	Relative to Reference Case (%)	Absolute Savings (million m^3/yr.)	Relative to Reference Case (%)	Absolute Savings (million m^3/yr.)	Relative to Reference Case (%)
2015	24,821	5,880	23.7%	5,299	21.3%	267	1.1%	195	0.8%	171	0.7%
2016	25,690	7,211	28.1%	6,096	23.7%	575	2.2%	414	1.6%	362	1.4%
2017	25,518	7,811	30.6%	6,205	24.3%	891	3.5%	631	2.5%	555	2.2%
2018	26,029	8,326	32.0%	6,290	24.2%	1,209	4.6%	859	3.3%	758	2.9%
2019	26,172	8,803	33.6%	6,369	24.3%	1,534	5.9%	1,094	4.2%	969	3.7%
2020	26,306	9,233	35.1%	6,448	24.5%	1,869	7.1%	1,338	5.1%	1,187	4.5%
2025	27,128	11,229	41.4%	6,891	25.4%	3,295	12.1%	2,276	8.4%	1,681	6.2%
2030	27,962	12,896	46.1%	7,409	26.5%	4,973	17.8%	3,468	12.4%	2,510	9.0%

Total technical potential: The results show that the adoption of all technically-feasible measures could reduce total consumption by 35.1% by 2020 and 46.1% by 2030.[4]

Total economic potential: Adoption of all measures that are economically viable (i.e. are cost-effective), have the potential to reduce total consumption by 24.5% by 2020 and 26.5% by 2030.

Total achievable potential: The unconstrained, semi-constrained, and constrained achievable potential scenarios could reduce total consumption by 7.1%, 5.1%, and 4.5%, respectively, by 2020, and by 17.8%, 12.4%, and 9.0%, respectively, by 2030.

Exhibit ES 4 Total Technical, Economic and Achievable Potential Savings and Program Cost Results[5]

Value	Unconstrained		Semi-Constrained		Constrained	
	Year					
	2020	2030	2020	2030	2020	2030
Annual Savings (million m^3/yr.)	1,869	4,973	1,338	3,468	1,187	2,510
Measure Lifecycle Savings (million m^3)	28,582	82,756	18,909	55,386	14,115	39,831
Value of Savings (million $)	16,456	96,600	12,938	78,266	9,142	58,628
Program Spending to Milestone Year (million $)	3,298*	11,544*	893	3,330	666	1,917
Average Annual Program Spending (million $/yr.)	550*	722*	149	208	111	120
Average Program Spending up to Milestone Year ($/$m^3$)	0.12*	0.14*	0.05	0.06	0.05	0.05

**Note: These are not specific program costs but are the total costs for the scenario.*

Unconstrained program results: With unconstrained budget, all sector programs combined could achieve 1,869 million cubic metres of annual savings, or 28.6 billion cumulative cubic metres of savings by 2020, at a total cost of $3.3 billion or on average $550 million per year. All sector programs combined could achieve 5.0 billion cubic metres of annual savings, or 82.8 billion cumulative cubic metres of savings by 2030, at a total cost of $11.5 billion or on average $722 million per year.

Semi-constrained program results: A program budget for all sectors of $893 million for 2015-2020, or $149 million per year, could achieve 1.3 billion cubic metres of annual savings, or 18.9 billion cumulative cubic metres of savings, by 2020. A program budget of $3.3 billion to 2030 could achieve 3.5 billion cubic metres of annual savings, or 55.4 billion cumulative cubic metres of savings, by 2030. This level of spending up to 2030 represents 29% of the total spending of the

[4] The large technically-feasible savings available are driven largely by the inclusion of electric air-source and ground-source heat pumps in the residential and commercial sectors of the study. Although these technologies do not currently pass the TRC-plus economic screen, they technically have the potential to eliminate a significant portion of the natural gas space heating in the province by 2030.

[5] The annual savings represent the natural gas saved each year by measures implemented in the years up to a milestone year.

The measure lifecycle savings present the natural gas saved over the lifetime of the measure installed up to that year, taking into account repeated installation of measures with lifetimes shorter than the period in question.

The value of the savings is the sum of the stream of avoided cost savings over the measure lifecycle for all the measures, with all savings discounted back to the year of installation.

The program spending to milestone year represents the sum of program spending for all years up to a given milestone year without discounting.

The average annual program spending is the total program spending up to a given milestone year divided by the number of years until that milestone year.

The average program spending up to milestone year is the total program spending divided by the total measure lifecycle savings.

unconstrained program, while the total lifecycle savings of natural gas represent 67% of the total savings of natural gas in the unconstrained program.

Constrained program results: Under budget allocations for all sectors of $666 million for 2015-2020, or $111 million per year, programs could achieve 1.2 billion cubic metres of annual savings, or 14.1 billion cumulative cubic metres of savings by 2020. Under a budget allocation of $1.9 billion to 2030, programs could achieve 2.5 billion cubic metres of annual savings, or 39.8 billion cumulative cubic metres of savings by 2030. This level of spending up to 2030 represents 17% of the total spending of the unconstrained program, while the total lifecycle savings of natural gas represent 48% of the total savings of natural gas in the unconstrained program.

Exhibit ES 5 shows the GHG emission reductions associated with the total natural gas savings shown in Exhibit ES 3. The percent reduction of GHG relative to the reference case for each scenario are the same as that of the natural gas savings in Exhibit ES 2. More details on this analysis can be found in chapter 2.

Exhibit ES 5 Total Greenhouse Gas Emission Reductions Under all Scenarios[6]

Year	Reference Case Emissions (million kg CO_2/yr)	Technical Potential		Economic Potential		Unconstrained Achievable Potential		Semi-constrained Achievable Potential		Constrained Achievable Potential	
		GHG Reduction (million kg CO_2/yr)	Savings Relative to Reference Case (%)	GHG Reduction (million kg CO_2/yr)	Savings Relative to Reference Case (%)	GHG Reduction (million kg CO_2/yr)	Savings Relative to Reference Case (%)	GHG Reduction (million kg CO_2/yr)	Savings Relative to Reference Case (%)	GHG Reduction (million kg CO_2/yr)	Savings Relative to Reference Case (%)
2015	46,241	10,955	23.7%	9,872	21.3%	498	1.1%	364	0.8%	318	0.7%
2016	47,860	13,434	28.1%	11,356	23.7%	1,072	2.2%	771	1.6%	675	1.4%
2017	47,541	14,552	30.6%	11,560	24.3%	1,659	3.5%	1,175	2.5%	1,033	2.2%
2018	48,492	15,512	32.0%	11,717	24.2%	2,252	4.6%	1,600	3.3%	1,413	2.9%
2019	48,759	16,401	33.6%	11,866	24.3%	2,858	5.9%	2,038	4.2%	1,805	3.7%
2020	49,008	17,201	35.1%	12,013	24.5%	3,482	7.1%	2,492	5.1%	2,212	4.5%
2025	50,539	20,920	41.4%	12,838	25.4%	6,138	12.1%	4,240	8.4%	3,132	6.2%
2030	52,093	24,025	46.1%	13,803	26.5%	9,265	17.8%	6,460	12.4%	4,677	9.0%

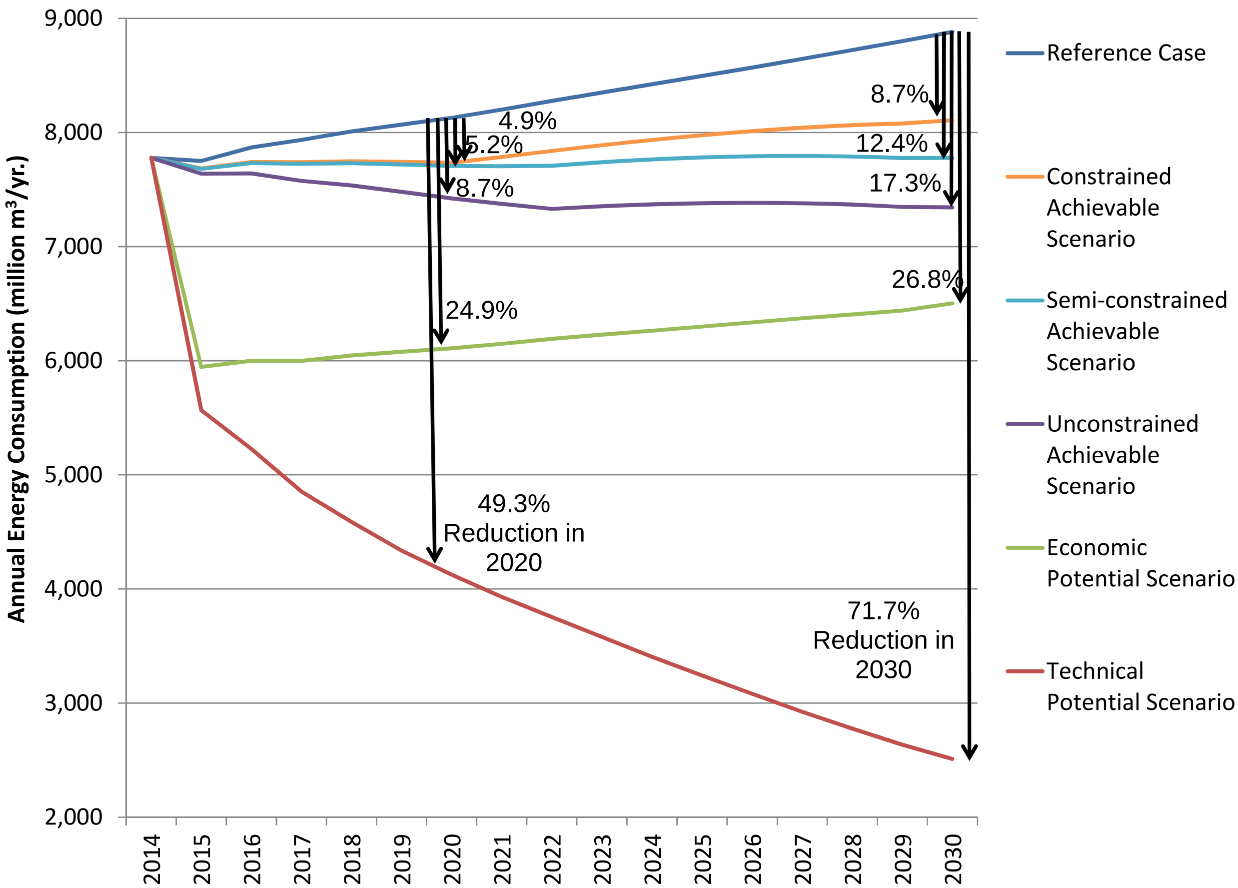
[6] The Guideline for Greenhouse Gas Emissions Reporting December 2015, Ministry of the Environment and Climate Change. recommends an emission factor of 1.863 kg CO_2/m^3 for natural gas in Ontario, which was used in this calculation http://www.downloads.ene.gov.on.ca/envision/env_reg/er/documents/2015/012-4549_d_Guideline.pdf

Summary of Natural Gas Savings Potential by Sector

Residential

Exhibit ES 6 shows the reference case natural gas use and savings associated with the technical, economic, unconstrained, semi-constrained, and constrained achievable potential savings for the residential sector over the entire study period

Exhibit ES 6 Residential Reference, Technical, Economic, and Achievable Potential Natural Gas Savings



Residential technical potential: The adoption of all technically-feasible measures could reduce residential consumption by 49.3% by 2020 and 71.7% by 2030, relative to the reference case. The large technically-feasible savings available are driven largely by the inclusion of electric air-source and ground-source heat pumps in the residential sector.

Residential economic potential: The adoption of all cost-effective measures could reduce residential consumption by 24.9% by 2020 and 26.8% by 2030. The decrease in savings from the technical potential to the economic potential is the result of the electric air-source and ground-source heat pumps not passing the cost-effectiveness screening test.

Residential achievable potential: The adoption of measures in the unconstrained, semi-constrained, and constrained achievable potential scenarios could reduce residential consumption by 8.7%, 5.2%, and 4.9%, respectively, by 2020, and of 17.3%, 12.4%, and 8.7%, respectively, by 2030.

Exhibit ES 7 shows the total annual savings in the residential sector for all scenarios until 2030 relative to the reference case.

Exhibit ES 7 Residential Technical, Economic, and Achievable Potential Annual Natural Gas Savings Relative to Reference Case

Year	Reference Case Use (million m³/yr.)	Technical Potential		Economic Potential		Unconstrained Achievable Potential		Semi-constrained Achievable Potential		Constrained Achievable Potential	
		Absolute Savings (million m³/yr.)	Savings Relative to Reference Case (%)	Absolute Savings (million m³/yr.)	Relative to Reference Case (%)	Absolute Savings (million m³/yr.)	Relative to Reference Case (%)	Absolute Savings (million m³/yr.)	Relative to Reference Case (%)	Absolute Savings (million m³/yr.)	Relative to Reference Case (%)
2015	7,751	2,185	28.2%	1,805	23.3%	110	1.4%	69	0.9%	65	0.8%
2016	7,871	2,643	33.6%	1,870	23.8%	230	2.9%	138	1.8%	130	1.6%
2017	7,934	3,079	38.8%	1,935	24.4%	357	4.5%	207	2.6%	194	2.4%
2018	8,009	3,422	42.7%	1,962	24.5%	474	5.9%	277	3.5%	260	3.2%
2019	8,070	3,735	46.3%	1,991	24.7%	590	7.3%	349	4.3%	326	4.0%
2020	8,130	4,006	49.3%	2,021	24.9%	708	8.7%	423	5.2%	395	4.9%
2025	8,496	5,253	61.8%	2,195	25.8%	1,115	13.1%	714	8.4%	519	6.1%
2030	8,882	6,371	71.7%	2,379	26.8%	1,539	17.3%	1,105	12.4%	774	8.7%

Exhibit ES 8 presents a summary of the residential (excluding low-income) sector achievable potential savings and program costs for each achievable potential scenario in 2020 and in 2030.

Exhibit ES 8 Residential (Excluding Low-Income) Achievable Potential Savings and Program Cost Results[7]

Value	Unconstrained		Semi-Constrained		Constrained	
	Year					
	2020	2030	2020	2030	2020	2030
Annual Savings (million m³/yr.)	503	1,109	330	845	307	553
Measure Lifecycle Savings (million m³)	8,506	18,675	3,321	11,266	2,629	7,516
Value of Savings (million $)	1,385	3,262	520	1,948	430	1,293
Program Spending to Milestone Year (million $)	1,298*	2,435*	318	1,161	235	657
Average Annual Program Spending (million $/yr.)	216*	152*	53	73	39	41
Average Program Spending up to Milestone Year ($/m³)	0.15*	0.13*	0.10	0.10	0.09	0.09

**Note: These are not specific program costs but are the total costs for the scenario.*

Residential unconstrained program results: With unconstrained budget, residential programs (excluding low-income) could achieve 503 million cubic metres of annual savings, or 8.5 billion cumulative cubic metres of savings by 2020, at a total cost of $1.4 billion or on average $216 million per year. Residential programs could achieve 1.1 billion cubic metres of annual savings, or 18.7 billion cumulative cubic metres of savings by 2030, at a total cost of $2.4 billion.

Residential semi-constrained program results: A program budget for the residential sector excluding low-income) of $318 million for 2015-2020, or $53 million per year, could achieve 330 million cubic metres of annual savings, or 3.3 billion cumulative cubic metres of savings, by 2020. A program budget of $1.2 billion to 2030 could achieve 845 million cubic metres of annual savings, or 11.3 billion cumulative cubic metres of savings, by 2030.

Residential constrained program results: Under current budget allocations for the residential sector (excluding low-income) of $235 million for 2015-2020, or $39 million per year, programs could

[7] See footnote 5 for details on the values in this table.

achieve 307 million cubic metres of annual savings, or 2.6 billion cumulative cubic metres of savings by 2020. Under a budget allocation of $657 million to 2030, or $41 million per year, programs could achieve 553 million cubic metres of annual savings, or 7.5 billion cumulative cubic metres of savings by 2030.

Exhibit ES 9 presents a summary of the low-income residential sector[8] achievable potential savings and program costs for each achievable potential scenario in 2020 and in 2030.

Exhibit ES 9 Low-Income Residential Achievable Potential Savings and Program Cost Results[9]

Value	Unconstrained		Semi-Constrained		Constrained	
	Year					
	2020	2030	2020	2030	2020	2030
Annual Savings (million m^3/yr.)	205	430	93	260	88	221
Measure Lifecycle Savings (million m^3)	2,246	5,399	1,002	3,731	859	2,829
Value of Savings (million $)	434	1,063	208	743	173	536
Program Spending to Milestone Year (million $)	447*	999*	148	536	108	302
Average Annual Program Spending (million $/yr.)	74*	62*	25	33	18	19
Average Program Spending up to Milestone Year ($/$m^3$)	0.20*	0.19*	0.15	0.14	0.13	0.11

**Note: These are not specific program costs but are the total costs for the scenario.*

Low-income residential unconstrained program results: With unconstrained budget, low-income residential programs could achieve 205 million cubic metres of annual savings, or 2.2 billion cumulative cubic metres of savings by 2020, at a total cost of $447 million or on average $74 million per year. Low-income residential programs could achieve 430 million cubic metres of annual savings, or 5.4 billion cumulative cubic metres of savings by 2030, at a total cost of $1.1 billion.

Low-income residential semi-constrained program results: A program budget for the low-income residential sector of $148 million for 2015-2020, or $25 million per year, could achieve 93 million cubic metres of annual savings, or 1 billion cumulative cubic metres of savings, by 2020. A program budget of $536 million to 2030 could achieve 260 million cubic metres of annual savings, or 3.7 billion cumulative cubic metres of savings, by 2030.

Low-income residential constrained program results: Under current budget allocations for the low-income residential sector of $108 million for 2015-2020, or $18 million per year, programs could achieve 88 million cubic metres of annual savings, or 859 million cumulative cubic metres of savings by 2020. Under a budget allocation of $302 million to 2030, or $19 million per year, programs could achieve 221 million cubic metres of annual savings, or 2.8 billion cumulative cubic metres of savings by 2030.

More details on the residential sector analysis can be found in chapter 4.

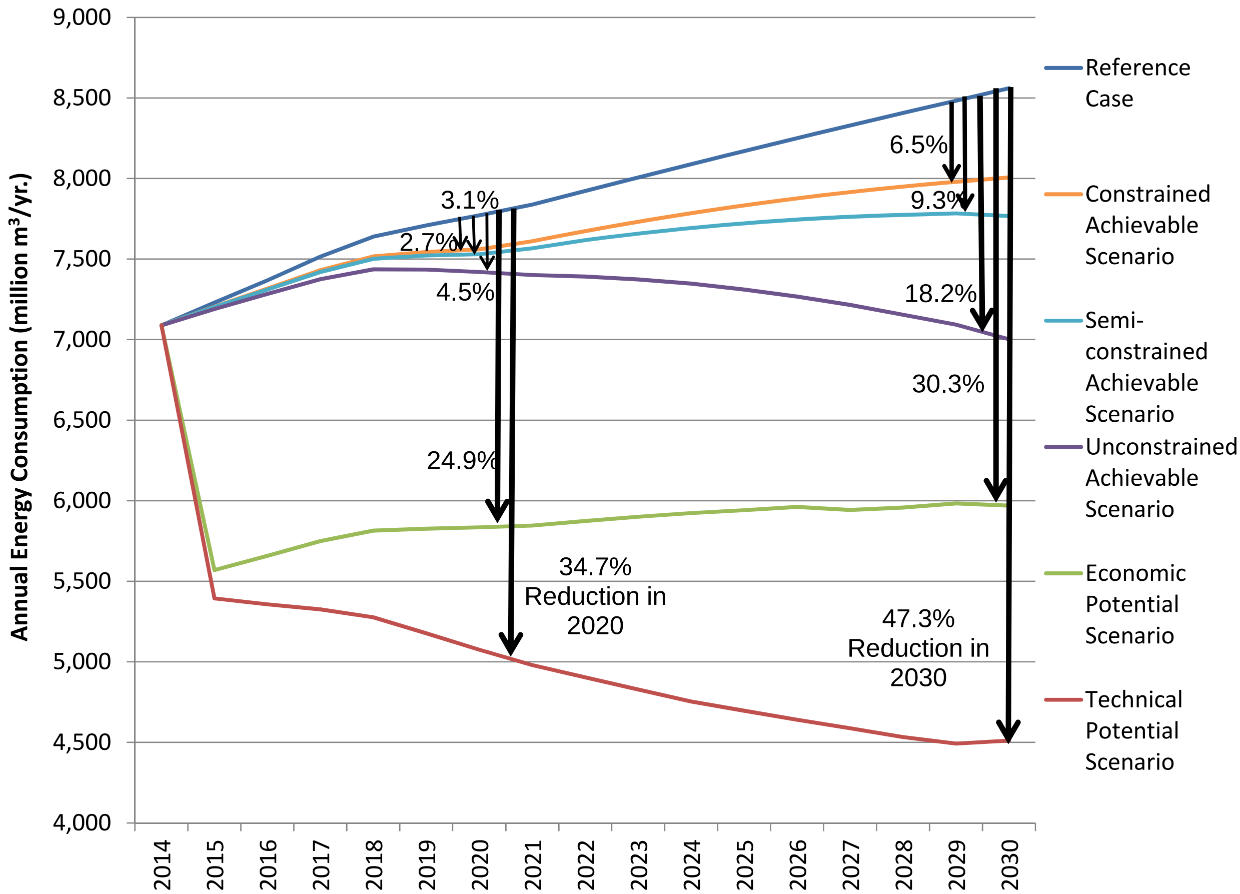
[8] The residential low-income sector includes single-family dwellings (attached and detached houses) whose occupants meet the low-income criteria set out in the OEB's 2015-2020 DSM Framework.

[9] See footnote 5 for details on the values in this table.

Commercial

Exhibit ES 10 below shows the comparison of the reference case, technical, economic, unconstrained, semi-constrained, and constrained achievable potential consumption volumes for the commercial sector over the entire study period.

Exhibit ES 10 Commercial Reference, Technical, Economic, and Achievable Potential Natural Gas Consumption



Commercial technical potential: The adoption of all technically-feasible measures could reduce residential consumption by 34.7% by 2020 and 47.3% by 2030. The large technically-feasible savings available are driven largely by the inclusion of electric air-source and ground-source heat pumps in the commercial sector.

Commercial economic potential: The adoption of all cost-effective measures could reduce residential consumption by 24.9% by 2020 and 30.3% by 2030. The decrease in savings from the technical potential to the economic potential are the result of the electric air-source and ground-source heat pumps not passing the cost-effectiveness screen.

Commercial achievable potential: The adoption of measures in the unconstrained, semi-constrained, and constrained achievable potential scenarios could reduce residential consumption by 4.5%, 3.1%, and 2.7%, respectively, by 2020, and of 18.2%, 9.3%, and 6.5%, respectively, by 2030.

Exhibit ES 11 shows the potential annual savings in the commercial sector for all scenarios until 2030, relative to the reference case.

Exhibit ES 11 Commercial Technical, Economic, and Achievable Potential Annual Savings Relative to Reference Case

Year	Reference Case Use (million m^3/yr.)	Technical Potential		Economic Potential		Unconstrained Achievable Potential		Semi-constrained Achievable Potential		Constrained Achievable Potential	
		Absolute Savings (million m^3/yr.)	Savings Relative to Reference Case (%)	Absolute Savings (million m^3/yr.)	Relative to Reference Case (%)	Absolute Savings (million m^3/yr.)	Relative to Reference Case (%)	Absolute Savings (million m^3/yr.)	Relative to Reference Case (%)	Absolute Savings (million m^3/yr.)	Relative to Reference Case (%)
2015	7,229	1,835	25.4%	1,659	23.0%	39	0.5%	26	0.4%	24	0.3%
2016	7,369	2,012	27.3%	1,711	23.2%	85	1.2%	58	0.8%	52	0.7%
2017	7,515	2,189	29.1%	1,766	23.5%	140	1.9%	95	1.3%	85	1.1%
2018	7,639	2,363	30.9%	1,825	23.9%	203	2.7%	138	1.8%	123	1.6%
2019	7,708	2,532	32.8%	1,881	24.4%	273	3.5%	187	2.4%	165	2.1%
2020	7,771	2,696	34.7%	1,936	24.9%	351	4.5%	241	3.1%	211	2.7%
2025	8,170	3,473	42.5%	2,229	27.3%	860	10.5%	449	5.5%	337	4.1%
2030	8,561	4,051	47.3%	2,592	30.3%	1,560	18.2%	794	9.3%	555	6.5%

Exhibit ES 12 presents a summary of the commercial sector (excluding low-income) achievable potential savings and program costs for each achievable potential scenario in 2020 and in 2030.

Exhibit ES 12 Commercial (excluding low-income) Achievable Potential Savings and Program Cost Results[10]

Value	Unconstrained		Semi-Constrained		Constrained	
	Year					
	2020	2030	2020	2030	2020	2030
Annual Savings (million m^3/yr.)	336	1,497	226	731	196	504
Measure Lifecycle Savings (million m^3)	4,324	24,804	3,239	11,918	2,710	7,907
Value of Savings (million $)	673	4,220	503	1,978	419	1,302
Program Spending to Milestone Year (million $)	396*	2,595*	214	785	157	442
Average Annual Program Spending (million $/yr.)	66*	162*	36	49	26	28
Average Program Spending up to Milestone Year ($/$m^3$)	0.09*	0.10*	0.07	0.07	0.06	0.06

**Note: These are not specific program costs but are the total costs for the scenario.*

Commercial unconstrained program results: With unconstrained budget, commercial programs (excluding low-income) could achieve 336 million cubic metres of annual savings, or 4.3 billion cumulative cubic metres of savings by 2020, at a total cost of $396 million or on average $66 million per year. Commercial programs could achieve 1.5 billion cubic metres of annual savings, or 24.8 billion cumulative cubic metres of savings by 2030, at a total cost of $2.6 billion.

Commercial semi-constrained program results: A program budget for the commercial sector (excluding low-income) of $214 million for 2015-2020, or $36 million per year, could achieve 226 million cubic metres of annual savings, or 3.2 billion cumulative cubic metres of savings, by 2020. A program budget of $785 million to 2030 could achieve 731 million cubic metres of annual savings, or 11.9 billion cumulative cubic metres of savings, by 2030.

Commercial constrained program results: Under current budget allocations for the commercial sector (excluding low-income) of $157 million for 2015-2020, or $26 million per year, programs could

[10] See footnote 5 for details on the values in this table.

achieve 196 million cubic metres of annual savings, or 2.7 billion cumulative cubic metres of savings by 2020. Under a budget allocation of $442 million to 2030, programs could achieve 504 million cubic metres of annual savings, or 7.9 billion cumulative cubic metres of savings by 2030.

Exhibit ES 13 presents a summary of the low-income commercial sector[11] achievable potential savings and program costs for each achievable potential scenario in 2020 and in 2030.

Exhibit ES 13 Low-income Commercial Achievable Potential Savings and Program Cost Results[12]

Value	Unconstrained		Semi-Constrained		Constrained	
	Year					
	2020	2030	2020	2030	2020	2030
Annual Savings (million m^3/yr.)	15	63	15	63	15	51
Measure Lifecycle Savings (million m^3)	178	1,001	178	1,001	178	872
Value of Savings (million $)	27	169	27	169	27	145
Program Spending to Milestone Year (million $)	27*	171*	27	171	27	131
Average Annual Program Spending (million $/yr.)	5*	11*	5	11	5	8
Average Program Spending up to Milestone Year ($/$m^3$)	0.15*	0.17*	0.15	0.17	0.15	0.15

**Note: These are not specific program costs but are the total costs for the scenario.*

Low-income commercial unconstrained program results: With unconstrained budget, low-income commercial programs could achieve 15 million cubic metres of annual savings, or 178 million cumulative cubic metres of savings by 2020, at a total cost of $27 million or on average $5 million per year. Low-income commercial programs could achieve 63 million cubic metres of annual savings, or 1 billion cumulative cubic metres of savings by 2030, at a total cost of $171 million. The program costs to 2020 are lower than the budgets available under both the constrained and semi-constrained scenarios and the program costs to 2030 are lower than the budgets available under the semi-constrained scenario. Therefore, the existing low-income commercial program budget would only ever be fully spent by 2030 under the aggressive version of the program.

Low-income commercial semi-constrained program results: A program budget for the low-income commercial sector of $27 million for 2015-2020, or $5 million per year, could achieve 15 million cubic metres of annual savings, or 178 million cumulative cubic metres of savings, by 2020. A program budget of $171 million to 2030 could achieve 63 million cubic metres of annual savings, or 1 billion cumulative cubic metres of savings, by 2030.

Low-income commercial constrained program results: Under current budget allocations for the low-income commercial sector of $27 million for 2015-2020, or $5 million per year, programs could achieve 15 million cubic metres of annual savings, or 178 million cumulative cubic metres of savings by 2020. Under a budget allocation of $131 million to 2030, programs could achieve 51 million cubic metres of annual savings, or 872 million cumulative cubic metres of savings by 2030.

More details on the commercial sector analysis can be found in chapter 5.

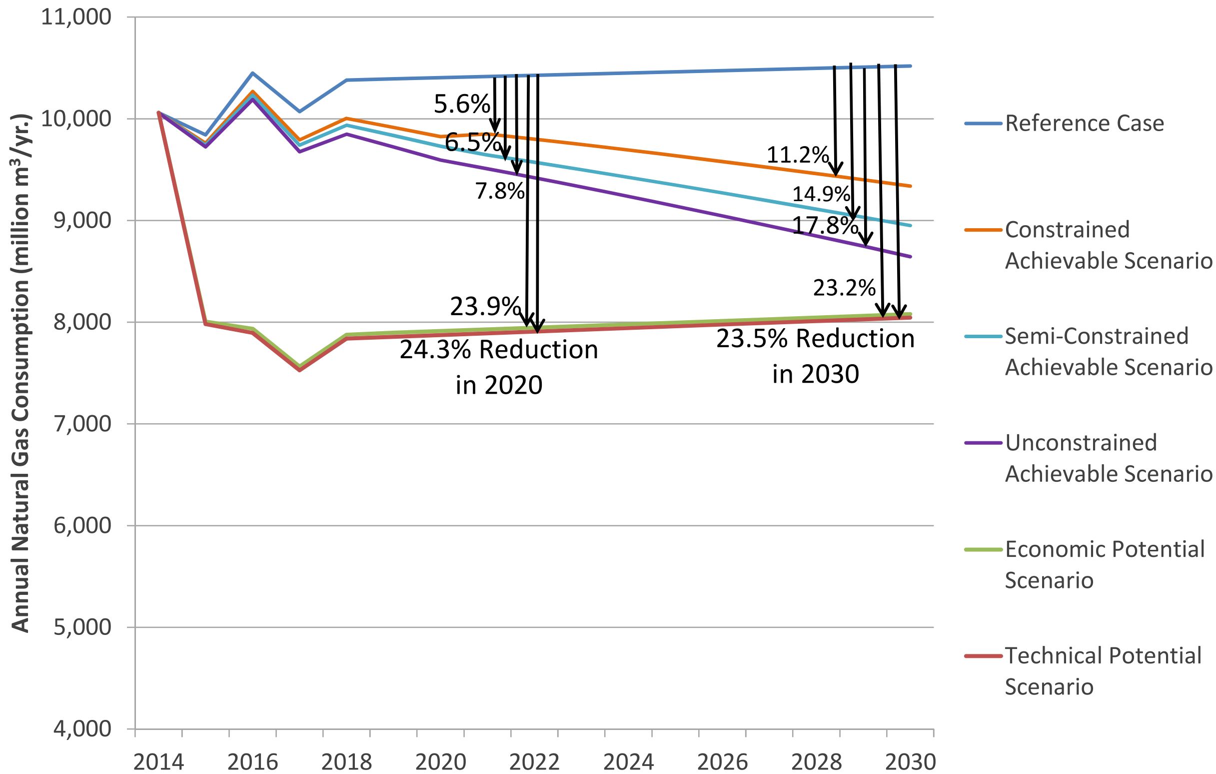
[11] Apartment buildings are included in the commercial sector because their energy use is more similar to a hotel or office building than to a house. Therefore low-income commercial refers to low-income apartment buildings.

[12] See footnote 5 for details on the values in this table.

Industrial

The results for the industrial sector show the achievable potential through increased DSM activity throughout Ontario until 2030. Exhibit ES 14 presents the reference case, technical, economic, unconstrained, semi-constrained, and constrained achievable potential consumption volumes for the industrial sector over the entire study period.

Exhibit ES 14 Industrial Reference, Technical, Economic, and Achievable Potential Natural Gas Consumption



Industrial technical results: The adoption of all technically-feasible measures could reduce industrial consumption by 24.3% by 2020 and 23.5% by 2030.

Industrial economic results: The adoption of all cost-effective measures could reduce industrial consumption by 23.9% by 2020 and 23.2% by 2030. The economic potential is very close to the technical potential as most of the measures modelled pass the TRC-plus test.

Industrial achievable results: The adoption of measures in the unconstrained, semi-constrained, and constrained achievable potential scenarios could reduce industrial consumption by 7.8%, 6.5%, and 5.6%, respectively, by 2020, and of 17.8%, 14.9%, and 11.2%, respectively, by 2030.

Exhibit ES 15 shows the total annual savings in the industrial sector for all scenarios up to 2030 relative to the reference case.

Exhibit ES 15 Industrial Technical, Economic and Achievable Potential Annual Savings Relative to Reference Case

Year	Reference Case Use (million m^3/yr.)	Technical Potential		Economic Potential		Unconstrained Achievable Potential		Semi-constrained Achievable Potential		Constrained Achievable Potential	
		Absolute Savings (million m^3/yr.)	Savings Relative to Reference Case (%)	Absolute Savings (million m^3/yr.)	Relative to Reference Case (%)	Absolute Savings (million m^3/yr.)	Relative to Reference Case (%)	Absolute Savings (million m^3/yr.)	Relative to Reference Case (%)	Absolute Savings (million m^3/yr.)	Relative to Reference Case (%)
2015	9,841	1,861	18.9%	1,835	18.6%	118	1.2%	100	1.0%	82	0.8%
2016	10,450	2,555	24.5%	2,515	24.1%	260	2.5%	218	2.1%	181	1.7%
2017	10,069	2,544	25.3%	2,504	24.9%	393	3.9%	328	3.3%	276	2.7%
2018	10,380	2,542	24.5%	2,502	24.1%	532	5.1%	443	4.3%	376	3.6%
2019	10,394	2,537	24.4%	2,497	24.0%	670	6.5%	558	5.4%	478	4.6%
2020	10,405	2,531	24.3%	2,492	23.9%	810	7.8%	674	6.5%	581	5.6%
2025	10,461	2,503	23.9%	2,466	23.6%	1,320	12.6%	1,113	10.6%	825	7.9%
2030	10,518	2,474	23.5%	2,438	23.2%	1,874	17.8%	1,569	14.9%	1,181	11.2%

Exhibit ES 16 presents a summary of the industrial (excluding large volume) achievable potential savings and program costs for each achievable potential scenario in 2020 and in 2030.

Exhibit ES 16 Industrial (Excluding Large Volume) Achievable Potential Savings and Program Cost Results[13]

Value	Unconstrained		Semi-Constrained		Constrained	
	Year					
	2020	2030	2020	2030	2020	2030
Annual Savings (million m^3/yr.)	460	1,073	433	1,008	398	813
Measure Lifecycle Savings (million m^3)	7,602	18,639	7,170	17,379	6,564	14,393
Value of Savings (million $)	7,950	49,826	7,498	46,457	6,864	38,475
Program Spending to Milestone Year (million $)	687*	3,186*	153	566	113	320
Average Annual Program Spending (million $/yr.)	115*	199*	26	35	19	20
Average Program Spending up to Milestone Year ($/$m^3$)	0.09*	0.17*	0.02	0.03	0.02	0.02

**Note: These are not specific program costs but are the total costs for the scenario.*

Industrial unconstrained program results: With unconstrained budget, industrial programs (excluding large volume) could achieve 460 million cubic metres of annual savings, or 7.6 billion cumulative cubic metres of savings by 2020, at a total cost of $687 million or on average $115 million per year. Industrial programs (excluding large volume) could achieve 1.1 billion cubic metres of annual savings, or 18.6 billion cumulative cubic metres of savings by 2030, at a total cost of $3.2 billion.

Industrial semi-constrained program results: A program budget for the industrial sector (excluding large volume) of $153 million for 2015-2020, or $26 million per year, could achieve 433 million cubic metres of annual savings, or 7.2 billion cumulative cubic metres of savings, by 2020. An industrial sector (excluding large volume) program budget of $566 million to 2030 could achieve 1.0 billion cubic metres of annual savings, or 17.4 billion cumulative cubic metres of savings, by 2030.

[13] See footnote 5 for details on the values in this table.

Industrial constrained program results: Under current budget allocations for the industrial sector (excluding large volume) of $113 million for 2015-2020, or $19 million per year, programs could achieve 398 million cubic metres of annual savings, or 6.6 billion cumulative cubic metres of savings by 2020. Under a budget allocation of $320 million to 2030, industrial programs (excluding large volume) could achieve 813 million cubic metres of annual savings, or 14.4 billion cumulative cubic metres of savings by 2030.

Exhibit ES 17 presents a summary of the large volume achievable potential savings and program costs for each achievable potential scenario in 2020 and in 2030.

Exhibit ES 17 Large Volume Industrial Achievable Potential Savings and Program Cost Results[14]

Value	Unconstrained		Semi-Constrained		Constrained	
	Year					
	2020	2030	2020	2030	2020	2030
Annual Savings (million m^3/yr.)	350	801	241	560	183	368
Measure Lifecycle Savings (million m^3)	5,726	14,238	3,999	10,090	1,174	6,313
Value of Savings (million $)	5,988	38,060	4,182	26,972	1,228	16,876
Program Spending to Milestone Year (million $)	442*	2,158*	33	110	26	65
Average Annual Program Spending (million $/yr.)	74*	135*	6	7	4	4
Average Program Spending up to Milestone Year ($/$m^3$)	0.08*	0.15*	0.01	0.01	0.02	0.01

**Note: These are not specific program costs but are the total costs for the scenario.*

Large volume industrial unconstrained program results: With unconstrained budget, large volume industrial programs could achieve 350 million cubic metres of annual savings, or 5.7 billion cumulative cubic metres of savings by 2020, at a total cost of $442 million or on average $74 million per year. Large volume industrial programs could achieve 801 million cubic metres of annual savings, or 14.2 billion cumulative cubic metres of savings by 2030, at a total cost of $2.2 billion.

Large volume industrial semi-constrained program results: A program budget for the large volume industrial sector of $33 million for 2015-2020, or $6 million per year, could achieve 241 million cubic metres of annual savings, or 4.0 billion cumulative cubic metres of savings, by 2020. A program budget of $110 million to 2030 could achieve 560 billion cubic metres of annual savings, or 10.0 billion cumulative cubic metres of savings, by 2030.

Large volume industrial constrained program results: Under current budget allocations for the large volume industrial sector of $26 million for 2015-2020, or $4 million per year, programs could achieve 183 million cubic metres of annual savings, or 1.2 billion cumulative cubic metres of savings by 2020. Under a budget allocation of $65 million to 2030, programs could achieve 368 million cubic metres of annual savings, or 6.3 billion cumulative cubic metres of savings by 2030.

More details on the industrial sector analysis can be found in chapter 6.

Sensitivity Analysis

In order to learn how changes to key variables would impact the study's results, two variables were manipulated as part of a sensitivity analysis:

- **Avoided cost** – increased by 50%. This higher avoided cost scenario was chosen to account for the possibility of higher commodity prices, natural gas price suppression effects, and a price on

[14] See footnote 5 for details on the values in this table.

carbon in the future. This change increased the number of measures that passed the TRC-plus cost-effectiveness test and therefore affected the economic and achievable potential scenarios.

- **Participation Rates** – the participation rates for all measures were increased by 20% to explore the effect of different levels of program success at a given level of program support.

Exhibit ES 18 shows the sensitivity results for all sectors.

Exhibit ES 18 Total Sensitivity Analysis Results

Scenario	Annual Savings (million m³)		Avoided Cost - 50% Increase				20% Participation Sensitivity			
			Annual Savings (million m³)		% Change		Annual Savings (million m³)		% Change	
	2020	2030	2020	2030	2020	2030	2020	2030	2020	2030
Economic Potential	6,448	7,409	7,484	9,181	16%	24%				
Unconstrained Potential	1,869	4,973	2,161	5,741	16%	15%	1,992	5,373	7%	8%
Semi-Constrained Potential	1,338	3,468					1,393	3,583	4%	3%
Constrained Potential	1,187	2,510					1,245	2,539	5%	1%

As shown in Exhibit ES 18, increasing the avoided costs by 50% increases the economic potential savings by 16% in 2020 and 24% in 2030. It also increases the unconstrained achievable potential savings by 16% in 2020 and 15% in 2030. The effects on the semi-constrained and constrained potential of varying the avoided cost were negligible, so these results were omitted. Similarly, there would be no effect on the economic potential resulting from varying the participation rate, so these results are also omitted.

These results show that the savings potential is less sensitive to participation, especially when the program spending budget is constrained or semi-constrained. A 20% increase in participation rates increases all the unconstrained, semi-constrained, and constrained achievable potential scenario savings results by 7%, 4%, and 5%, respectively, in 2020. In 2030, the annual savings increases by 8%, 3%, and 1%, for the unconstrained, semi-constrained and constrained achievable potential scenarios, respectively. In both the residential and commercial sector, the additional measures were relatively expensive compared to the measures that were already part of the original achievable constrained and semi-constrained scenarios, limiting any additional measures to the constrained and semi-constrained scenarios under the participation sensitivity scenario.

More details on this analysis can be found in chapter 7.

Comparison with Prior Potential Studies

The overall technical potential natural gas savings estimated in this study (46%) is higher than the technical potential savings that were identified by Navigant in their 2015 study for Enbridge Gas Distribution[15] (35%) and for Minnesota[16] (36%). However, the time periods considered in each of these studies was different, so it is more appropriate to consider annual technical potential savings, which were 3.1% in this study, 3.5% in the Navigant Enbridge Gas Distribution study, and 3.6% in the Navigant Minnesota study. These results indicate that the technical potential results of this study are slightly more conservative than those of the other two studies.

In this study, the economic potential savings were estimated to be 26% by 2030, or about 1.8% annually, versus the Navigant Enbridge Gas Distribution study estimate of 25%, or 2.5% annually.

[15] Natural Gas Energy Efficiency Potential Study 2014-2024 prepared for Enbridge, Navigant, 2015.

[16] Minnesota Gas Energy Efficiency Potential Study, Navigant, 2009. As reviewed by ACEEE in: Cracking the TEAPOT: Technical, Economic, and Achievable Energy Efficiency Potential Studies, ACEEE, 2014.

The economic potential savings from the other ICF/Marbek studies[17] were also found to be higher than those of the current study. Some of these differences are likely due to different avoided costs between the studies, as well as slightly increased penetration of the various measures since the previous studies were completed, due to ongoing initiatives.

The annual achievable potential results in this study are quite similar in magnitude to the results of the Navigant Enbridge Gas Distribution study, with both studies estimating annual achievable potential savings of 0.8%.

More details can be found in chapter 8.

Recommendations

Conservation potential studies for the province of Ontario are expected to be conducted on a three-year cycle. The purpose of this section is to identify ways to enhance the next natural gas conservation study, both by capturing some of the successful features of this study and by improving on other aspects.

Successes to Retain

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

- The Technical Working Group (TWG) was dedicated to producing a good study, and provided review and constructive feedback that the consultants found extremely valuable. It was important that the group represented a variety of perspectives.
- The development of technical reference manual (TRM) documents prior to the beginning of the study was a valuable contribution. Ideally, a definitive set of TRM substantiation documents should be compiled before the next request for proposals is released, so that it can be made available to bidders.
- The availability of recent end use surveys from the gas utilities was valuable for both the residential and commercial sectors.[18] The next end use surveys should be timed to produce results before the next request for proposals is released.

Recommended Improvements

Aspects of the current study that could be improved in the next study include the following:

- The next study should have a longer timeframe for completion. In particular, this extended period would allow for more detailed review and more flexibility for the contractor to make modelling changes in response to feedback.
- The next study should consider using a modified Delphi workshop approach to developing estimates of measure participation. The interview approach used in this study worked adequately well, but the process is enhanced when there is real-time interaction between interviewees with varying viewpoints.
- If the natural gas and electricity conservation potential studies will be occurring simultaneously next time, the next study should include some opportunities for collaboration between them. This interaction would potentially enhance the study in several ways, including:

[17] Natural Gas Energy Efficiency Potential Study Update 2007-2017, prepared for Union Gas, ICF Marbek, 2011.

Conservation Potential Review 2010-2030, prepared for Fortis BC, ICF Marbek, 2011.

Natural Gas Energy Efficiency Potential Update 2007-2017, prepared for Enbridge, Marbek, 2008.

[18] It should be noted that the scope and accuracy of future commercial end use surveys could be improved significantly. In addition, questions should focus on the distribution of energy consumption for different types of equipment.

  - The reference case could include improved estimates of the effects of conservation activities by other actors, particularly the electric utilities
  - More comprehensive electricity and water savings could be included in the assumptions about the measures
  - Measures that save both electricity and gas could be included in programs operated jointly between the gas and electric utilities. This could be reflected in the program cost assumptions for both studies (i.e., the program costs could be reduced on the gas side if part is to be paid by the electric utility).
  - Fuel switching should be included in the scope of the study
- It should be defined clearly where a conservation potential study ends and where program planning begins. Development of program cost assumptions for the measures, and optimization of which measures can be included in specified budgets must be relatively mechanical procedures in the context of a conservation potential study looking at dozens or hundreds of conservation measures. Subsequent program planning will repeat much of this effort in greater detail and based on more robust data. In the next study, it may be helpful to place clear limits on the level of detail and accuracy expected of the program costing component of the study.
- The program costing component of the next study may also be enhanced by including a stage where the consultant assembles the various measures into program bundles. The optimization process of estimating how much program activity could be accomplished for specified budget levels would then be conducted at the bundle level, rather than at the level of individual measures. This would likely reduce the savings estimate slightly, but may be a simpler approach.
- The results of the next study could be enhanced by making more use of empirical data from existing programs and building improvement projects, to “ground truth” the savings that are achievable from real measures applied to real buildings.
- If the next study is to identify savings for specific sub-sectors, such as large volume industrial customers or low-income residential customers, data divided according to these categories should be provided to the consultant performing the study. For example, residential end use surveys targeting the low-income sector specifically would be very useful.
- Measure savings in the present model are based on baseline efficiencies representing the average in each category of buildings. For example, in residential, savings for an insulation measure would be calculated based on the average baseline insulation in a given vintage of dwellings. This does not capture the range of possible insulation levels in that group of dwellings. The next study could be enhanced by including several variants of certain measures, in order to capture niche markets in which they may be more economically attractive.
- The sensitivity analysis in the next study would be enhanced through varying more parameters and including more points for each parameter.
- The Ontario government released its Climate Change Action Plan while this study was being completed.[19] Subsequent studies and any updates to this study should account for the impacts of this plan.

[19] Ontario’s Five Year Climate Change Action Plan: 2016-2020, Ontario Ministry of Environment and Climate Change, 2016, available at: http://www.applications.ene.gov.on.ca/ccap/products/CCAP_ENGLISH.pdf

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1 Introduction

Charged with regulating Ontario's natural gas and electricity sectors, the Ontario Energy Board (OEB) was directed by the Minister of Energy to have an achievable potential study completed for natural gas efficiency in Ontario.

The objective of this study is to estimate the achievable potential for natural gas efficiency in Ontario from 2015 to 2030, in order to:

- Inform natural gas Demand Side Management (DSM) program design and delivery at the mid-term review of the 2015-2020 DSM Framework
- Provide guidance to utilities for DSM program design and delivery beyond 2020
- Support the assessment of the role that DSM may serve in future distribution infrastructure planning processes at the regional and local levels

  The scope of this work includes the planning and execution of an achievable potential study in the franchise areas of Union Gas Limited ("Union Gas") and Enbridge Gas Distribution Inc. ("Enbridge Gas Distribution") collectively referred to as the "utilities". This study builds on the past natural gas utility achievable potential work as well as the OEB's 2015-2020 DSM Framework, the 2015-2020 DSM plans prepared by Union Gas and Enbridge Gas Distribution, annual reports of the utilities to the OEB, the 2015-2020 DSM Decision, DSM program evaluations, and other studies on DSM market characterization and technology assessments. This study also leverages input from the DSM Technical Working Group (TWG), which included experts proposed by stakeholders and representatives from the utilities, Independent Electricity System Operator, Ministry of Energy, and Environmental Commissioner of Ontario.

Given the emergence of the cap and trade initiative since the study was initiated, the carbon impacts were not included in the avoided costs analysis. It was determined that it would be prudent to defer consideration of the issue until final details related to the cap and trade initiative are available to inform the analysis. Instead, a sensitivity analysis has been undertaken to provide a preliminary assessment of what will be the impact of higher avoided costs on the economic potential.

1.1 Study Scope

The scope of this study is summarized below:

- **Sector Coverage:** The study addresses three sectors: residential, commercial[20] and industrial.
- **Geographical Coverage**: The study results are presented for the total Union Gas and Enbridge Gas Distribution franchise areas and further broken down into the regions shown in Exhibit 1.

Exhibit 1 Breakdown of Utility Franchise Areas and Regions

Utility	Union Gas	Enbridge Gas Distribution
Region	Northern[21]	Central
	Southern[22]	Eastern

[20] Throughout this report the term "commercial" also includes institutional sectors, such as schools, hospitals, etc., unless otherwise noted.

[21] Throughout Northern Ontario, from the Manitoba border to the North Bay/Muskoka area and across Eastern Ontario from Port Hope to Cornwall

[22] Southwestern Ontario from Windsor to just west of Toronto.

- **Study Period**: This study covers a 17-year period from 2014 to 2030. The base year for the study is the calendar year 2014. The base year of 2014 was calibrated to the 2014 actual sales data provided by the gas utilities.
- **Technologies:** The study addresses the full range of natural gas energy efficiency measures

1.2 Data Caveats

As in any study of this type, the results presented in this report are based on a number of additional important assumptions. Those assumptions include the current penetration of measures and the rate of future growth in the building stock. Wherever possible, the assumptions used in this study are consistent with those used by the OEB and the utilities. As such, the reader should use the results presented in this report as best available estimates; major assumptions, information sources, and caveats are noted throughout the report.

1.3 Report Organization

This report presents the results for the residential, commercial, and industrial sectors. It is organized and presented as follows:

- Chapter 2 presents the methodology used by ICF to evaluate to complete the analysis.
- Chapter 3 presents the avoided costs analysis and results.
- Chapter 4 presents the results from the residential sector, including the measure potential savings, base year, reference forecast, technical potential, economic potential, achievable potential, and sensitivity analysis.
- Chapter 5 presents the results from the commercial sector, including the measure potential savings, base year, reference forecast, technical potential, economic potential, achievable potential, and sensitivity analysis.
- Chapter 6 presents the results from the industrial sector, including the measure potential savings, base year, reference forecast, technical potential, economic potential, achievable potential, and sensitivity analysis.
- Chapter 7 presents the summarized achievable potential results for all sectors.
- Chapter 8 presents a comparison of this study's results to other potential studies.
- Chapter 9 presents study recommendations.
- Appendix A includes a glossary of terms.
- Appendix B includes tables of measure descriptions for each sector.
- Appendix C includes a table summarizing any modifications to the utilities' previously filed measure input assumptions. This excludes current technical reference manual (TRM) measures.
- Appendix D presents the detailed calculations behind the constrained and semi-constrained budgets.

1.4 Definition of Terms

This study employs numerous terms that are unique to analyses such as this one and consequently it is important to ensure that readers have a clear understanding of what each term means when applied to this study. A full glossary of terms is provided in Appendix A of this report. Below is a brief description of some of the most important terms:

Base Year Natural Gas Use
The Base Year is the starting point for the analysis. It provides a detailed description of "where" and "how" natural gas is currently used in each sector. The bottom up profile of energy use patterns and market shares of energy-using technologies was calibrated to actual Union Gas and Enbridge Gas Distribution customer sales data. For this study, the base year is the calendar year 2014.

Reference Case Forecast
The Reference Case is a projection of natural gas consumption from 2015 to 2030 that includes natural conservation (which would already occur, even in the absence of DSM programs) but no impacts of utility DSM programs. The reference case for the study is based on the 2014 base year and the utilities' load forecasts. It is the baseline against which the scenarios of energy savings are calculated.

Measure Total Resource Cost Plus (TRC-plus) Test
The measure TRC-plus is a cost/benefit analysis of the net present value of energy savings that result from an investment in an efficiency or fuel choice technology or measure. The measure TRC-plus calculation considers a measure's full or incremental capital cost (depending on application) plus any change (positive or negative) in the combined annual energy and operation and maintenance (O&M) costs. This calculation uses the avoided natural gas price with a 15% non-energy benefit adder,[23] electricity supply costs, the life of the technology, and the selected discount rate. In this study, TRC-plus is expressed as a ratio of benefits divided by costs, with both the numerator and denominator calculated as net present values.

A technology or measure with a TRC-plus benefit/cost ratio of 1.0 or greater is included in the technical, economic, and achievable potential analyses. A measure with a TRC-plus benefit/cost ratio below 1.0 is not considered economically attractive and is therefore included only in the technical potential analysis Consistent with OEB DSM Guidelines, a lower benefit/cost ratio threshold of 0.7 was used for measures applied to low-income sub-sectors in the residential and commercial sectors.

Technical Potential
The technical potential is the total natural gas savings resulting from the implementation of all technically feasible energy efficiency measures, regardless of cost effectiveness or market acceptance.

Economic Potential
The economic potential is the total natural gas savings resulting from the implementation of all measures included in the technical potential that also pass the TRC-plus cost effectiveness screening, regardless of market acceptance.

Achievable Potential
The achievable potential analysis takes into account realistic market penetration rates of cost-effective measures over the study period based on a number of factors including market barriers, customer preference and acceptance based on payback periods, return on investment (ROI), investment hurdle rates and other factors.

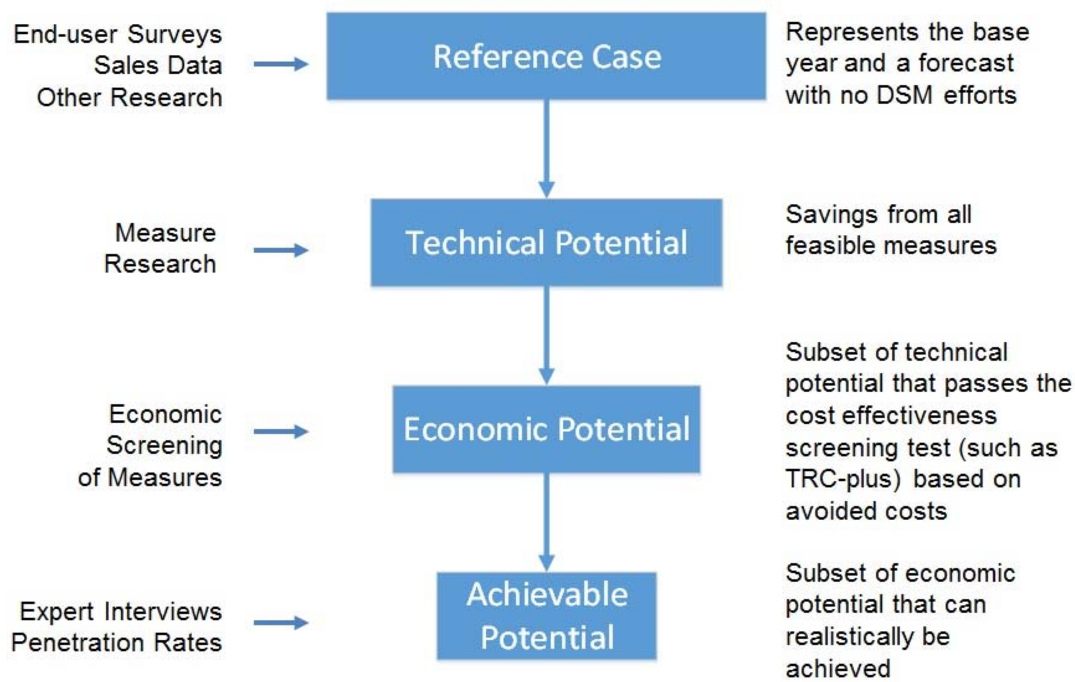
[23] The 15% adder accounts for the non-energy benefits associated with DSM programs, such as environmental, economic, and social benefits, as selected by the OEB in 2015-2020 DSM Framework. It is aligned with the cost effectiveness test used by the IESO, as per the Minister of Energy's Conservation First Framework.

2 Methodology

A conservation potential study is a quantitative analysis that indicates the amount of energy efficiency available in three forms: first, in aggregate and without any limitations (technical potential); next, energy efficiency that is cost-effective (economic potential); last, energy efficiency that can actually be implemented and that takes policy and market factors into consideration (achievable potential).

As shown in Exhibit 2, a conservation potential study is normally composed of four main areas: the development of a reference case; a technical potential scenario; and economic scenario; and an achievable potential scenario. The details and subsets of each of these areas is discussed in detail in this chapter.

Exhibit 2 General methodology for potential studies



2.1 Measures and Input Assumptions

This section describes the following considerations with regards to the energy efficiency measures and the related input assumptions:

- Measure identification
- Measure characterization
- Measure simple payback period (from the customer's perspective)
- Total Resource Cost-Plus (TRC-plus)

A brief discussion of each consideration is provided in the following sub-sections.

2.1.1 Measure Identification

The initial measure list was developed beginning with the utilities' annually-filed input assumptions including those revised for the new Technical Reference Manual (TRM)[24] developed by the utilities and the Technical Evaluation Committee (TEC) throughout 2015 and 2016.[25] ICF recognizes the level of investment required to develop a TRM and the need to use a consistent set of measure assumptions already used in the province. ICF reviewed the input assumptions to identify any concerns with the measure characterization used in the TRM. All assumptions used in the study align with assumptions defined in the filed input assumptions. ICF also employed input assumptions for measures filed in previous years, although some minor adjustments were required for a small subset of these measures to ensure the greatest level of accuracy.

The list was then expanded to include energy efficiency measures from ICF's database, which includes all measures ICF has included in previous natural gas conservation potential studies that are not in the utilities' filed input assumptions.[26] Custom, or placeholder, measures were developed for the commercial and Industrial sectors; these measures rely heavily on information from existing custom projects and data provided by the utilities on emerging measures, including technologies that are new to the market or that are commercially available but underused and expected to reach full commercialization during the study period, and technologies likely to emerge during the study period but that are not yet market-ready.

The development of the measure list was an iterative process. The final list contained 52 residential measures, 59 commercial measures and 57 industrial measures. A table of measures with their descriptions is provided for each sector in Appendix B. A table of input assumption adjustments is provided in Appendix C.

2.1.2 Measure Characterization

Measure input assumptions and parameters include incremental costs, natural gas savings (cubic metres), other resource savings (other fuels and water), effective useful life, measure applicability, and classification into measure types. The measures are mapped to specific sectors, sub-sectors and end uses. Some parameters, such as costs or performance, are expected to change over the course of the study period and have been adjusted to reflect this. If no information is available or no changes to parameters are expected, the parameters are held constant. In the case of weather-sensitive measures not currently in the TRM, ICF employed targeted building simulations to estimate savings and interactive effects.[27] The measures for which this is most important are typically the building envelope measures in the residential and commercial sectors.

Information on the cost of implementing each measure was also compiled from secondary sources, including both the measure's full cost and incremental cost in comparison to baseline equipment.

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[24] Based on TEC stakeholder terms of reference, available at: http://www.ontarioenergyboard.ca/documents/TEC/Committee%20Guiding%20Documents/Stakeholder%20Engagement%20ToR.pdf,

"The TRM will be common to both Union and EGD and will document efficiency measure savings assumptions (and/or formulae) and all other assumptions (other than avoided costs) necessary for cost-effectiveness screening and program metrics. Input assumptions and formulae may be unique for each utility."

[25] The TRM will be filed with the OEB and posted on the OEB's website.

[26] For the residential sector, ICF conducted targeted building modelling using HOT2000 building modelling software (http://www.nrcan.gc.ca/energy/efficiency/housing/home-improvements/17725) to determine the potential savings of building envelope measures and several behavioural measures such as thermostat setbacks and use of blinds. For the commercial sector, ICF determined the potential savings of building envelope measures using targeted building modelling conducted in EnergyPlus (http://apps1.eere.energy.gov/buildings/energyplus/).

[27] For example, ICF used HOT2000 to estimate the impact of some residential envelope measures, while ICF used EnergyPlus for the same purpose in the commercial sector analysis.

The incremental cost is applicable when a measure is installed in a new facility or at the end of its useful life in an existing facility; in this case, incremental cost is defined as the difference in cost between the energy efficient option relative to the "baseline" technology. The full cost is applicable when an operating piece of equipment is replaced with a more efficient model or a fuel choice option prior to the end of its useful life. Many measures were evaluated under both scenarios, allowing measures that were too expensive to be viable before the existing equipment reaches the end of its life to be retested under the incremental scenario. An explanation of the economic cost test used in this study is provided in section 2.3.

In both cases, the costs and savings are annualized,[28] based on the number of years of equipment life and the discount rate, and the costs incorporate applicable changes in annual O&M costs. All costs are expressed in constant (2014) dollars.

2.1.3 Measure Evaluation from Customer's Prospective (Simple Payback Period)

The simple payback is generated to show the attractiveness of a measure from the customer's financial perspective. Simple payback is "a measure of the length of time required for the cumulative savings from a project to recover its initial investment cost and other accrued costs, without taking into account the time value of money. The simple payback period is usually measured from the service date of the project."[29] The cost of the measure (incremental or full, as appropriate) is divided by the expected annual savings. The answer is given in years.

The following equation illustrates how this calculation is applied to a situation where an upgrade has a higher upfront cost than the baseline technology, but lower ongoing operating costs:

Payback (years) = (CostUpgr – CostBase)/(AnnBase – AnnUpgr)

where, CostUpgr = initial capital cost of the upgrade measure ($)
CostBase = initial capital cost of the baseline measure ($)
AnnUpgr = ongoing operating cost[30] of the upgrade ($/year)
AnnBase = ongoing operating costs of the baseline technology ($/year)

In addition to being a useful indicator of measure cost-effectiveness from a customer's perspective, simple payback was used to assist in developing an estimate of program costs associated with each measure.[31]

2.1.4 Measure Market Penetration and Applicability Factors

Assumptions for baseline market penetration of measures begin with an assumed penetration in the base year of the study. The residential sector assumptions for base year penetration were drawn from ICF's experience and supplemented by the residential end use surveys conducted by the utilities.

[28] Annualizing costs and savings involves converting one-time costs and/or streams of costs and savings into an annual equivalent based on the lifetime of a particular measure and a discount rate, as appropriate. This allows for an "apples-to-apples" comparison of costs and savings.

[29] U.S. Department of Energy, "Life-Cycle Costing Manual for the Federal Energy Management Program".

[30] Fuel and maintenance costs

[31] During the achievable potential interviews, where interviewees identified payback as an important driver of adoption, the estimate of required payback period, combined with the capital cost of the measure, was used to estimate the required incentive. This was combined with the estimated non-incentive program support expenses to estimate the program costs associated with a measure. An estimated program cost for each measure was required in order to estimate the savings that could be achieved within the constrained and semi-constrained budget limits.

Future penetrations require estimates of the naturally-occurring adoption of the efficiency measures. The overall applicability would be the product of the fraction-of-end use applicability and the technical barrier applicability. The methods used to estimate future penetrations varied by sector and are therefore discussed in the sector-specific chapters of this report, found in chapters 4, 5, and 6.

2.2 Avoided Costs

Avoided costs[32] are one of the key components of the cost-effectiveness tests that are used to evaluate energy efficiency investments. Cost-effectiveness represents whether an investment's benefits exceed its cost. A detailed description of the avoided cost analysis is provided in chapter 3.

2.3 Measure Total Resource Cost-Plus (TRC-plus)

The measure TRC-plus is a cost/benefit analysis of the net present value of energy savings that result from an investment in an efficiency or fuel choice technology or measure. The measure TRC-plus calculation considers a measure's full or incremental capital cost (depending on application) plus any change (positive or negative) in the combined annual energy and operation and maintenance (O&M) costs. This calculation uses the avoided natural gas price with a 15% non-energy benefit adder,[33] electricity supply costs, the life of the technology, and the selected discount rate. In this study, TRC-plus is expressed as a ratio of benefits divided by costs, with both the numerator and denominator calculated as net present values. [34]

A technology or measure with a TRC-plus benefit/cost ratio of 1.0 or greater is included in the technical, economic, and achievable potential analyses. A measure with a TRC-plus benefit/cost ratio below 1.0 is not considered economically attractive and is therefore included only in the technical potential analysis Consistent with OEB DSM Guidelines, a lower benefit/cost ratio threshold of 0.7 was used for measures applied to low-income sub-sectors.

With regards to measure persistence, in this study measures are assumed to persist for their full expected measure life and to be replaced at similar TRC-plus ratios if their lifetime is shorter than the study period. In the economic potential estimate, no customers remove efficient measures once installed, and no one "falls back" to the standard technology after the measure reaches end of life. For measures whose TRC-plus ratio is just below the threshold at the beginning of the study, they will be retested using the stream of avoided costs applicable to measures applied at the end of the study. If they pass the TRC-plus test under those circumstances, they will be included in the economic potential, but with adoption initially suppressed until the year when they begin to pass.

It should be noted that the measure TRC-plus provides an initial screen of the technical options. Considerations such as program delivery costs, incentives, etc., are incorporated in later detailed program design stages, which are beyond the scope of this study.[35] To some extent, these factors will be considered during the achievable potential phase of the study, through adjustment of expected adoption (or participation) rates for the measures. Measures whose success within

[32] The avoided cost is the marginal cost for a utility to supply one more unit of energy. The natural gas avoided costs used in this study include the direct natural gas supply and infrastructure costs that can be avoided by the utilities as a result of a decrease in demand, resulting from a reduction in load attributed to the conservation program, as well as other avoided costs not paid directly by the utilities. See Section 3 for additional details on the development of avoided costs for this study.

[33] See footnote 23 for a description of the 15% adder.

[34] Measure TRC-plus results do not include program costs such as program administrative (non-incentive) costs and adjustments for free ridership, spillover effects, and persistence etc. Measure TRC-plus results were used for preliminary screening of measures for inclusion in the economic potential.

[35] Although the utilities' current program designs/structures were a reference point for this study, the assumptions used in this study are independent of these programs.

programs would be problematic because high program administrative or incentive costs would likely overwhelm their marginal benefits will be assigned low (or zero) participation rates to account for these factors.[36]

2.4 Base Year Natural Gas Energy Use

The Base Year is the starting point for the analysis. It provides a detailed description of “where” and “how” natural gas is currently used in each sector. The bottom up profile of energy use patterns and market shares of energy-using technologies was calibrated to actual Union Gas and Enbridge Gas Distribution customer sales data. For this study, the base year is the calendar year 2014.

Completion of this section of the study involved the following steps:

- Utility customers were segmented into sub-sectors containing buildings with similar energy-use patterns
- The major energy end uses within each sector were selected
- Detailed sub-sector archetypes developed and these archetypes were used to create building energy-use models for each sub-sector

2.5 Reference Case

The reference case includes the ongoing effects of DSM activity initiated before the study period, and also includes the effects of DSM activity by other actors in the market, such as electricity utilities. The reference case also presents a scenario in which policy, legislation, and regulation continue to exist as they are today. The inclusion of these first two areas of DSM activity into the reference case ensures that all natural conservation has been considered. Legislation that is not yet passed or clearly mapped out is subject to influence and is therefore considered within the realm of potential savings. As such, the reference case provides the point of comparison for the calculation of new energy saving opportunities associated with each of the scenarios that are assessed within this study.

Completion of this section of the study involved the following steps:

- The detailed profiles of new buildings (those buildings expected to be constructed during the study period) were updated for each sub-sector in each service region. Changes in building envelope and equipment affecting energy consumption were noted.
- The growth in building floor space was estimated for each sub-sector within each service region.
- Naturally-occurring efficiency changes affecting annual natural gas use in existing buildings were estimated.
- Special consideration was given to three factors:
    - Naturally-occurring improvements in equipment efficiency
    - Expected penetration of more efficient equipment into the building stock
    - Known, upcoming changes in building and equipment energy performance codes and standards.
- Changes in natural gas share for each end use were estimated.

[36] The zoned-up windows measure was an example of a residential measure whose assumed incentive level, based on interview discussions of building envelope measures, was high relative to the value of the gas savings it would provide. The participation levels were set to zero for this measure. The ratio for the super high-performance windows was more attractive, and it was included in the potential.

- The inputs from the preceding steps were entered into each sector model and estimates of natural gas use throughout the study period were generated.
- For all sectors, the load growth was modelled based on the utilities' forecasts for each sector, excluding the effects of any discrete and incremental DSM efforts.[37]

Please note that the reference case does not account for initiatives related to the Climate Change Action Plan. It is anticipated that some of these initiatives would reduce gas consumption in the reference case forecast, which would reduce the achievable potential savings found in this study.

2.6 Technical Potential

In order to assess the technical potential savings that would result from the application of the energy efficiency measures, the measures were compared to the reference case consumption and reference case penetration of each technology, as was briefly described in section 2.1.4.

The considerations included in the technical potential methodology are described in the following sub-sections.

2.6.1 Measure Interactive Effects

In order to account for interactive effects between measures, the ICF model used what is referred to as cascading. Cascading accounts for the fact that measures can be implemented in parallel (i.e. there are no interactive effects), in sequence (i.e. there are interactive effects), or can be mutually exclusive (i.e. only one measure or the other may be selected). An example of parallel measures is roof insulation and wall insulation, which can be implemented together and do not affect each other, even though they will both reduce space heating energy use. An example of mutually exclusive measures are 90% efficient boilers and 92% efficient boilers, because only one or the other can be implemented at once, not both. Without cascading, the cumulative savings potential would be overestimated.

Measures are generally included in the cascade in the following order: measures that reduce load (such as building envelope improvements), equipment measures, control measures, and behaviour measures. This approach takes into account the savings available from measures that would represent a long-term missed opportunity if not implemented. If these more expensive measures fail the economic screen, their savings drop to zero in the economic potential calculation and they no longer reduce the savings attributed to the control and behaviour measures later in the cascade order.

2.6.2 Penetration-Adjusted Savings

The ICF model estimates measure savings by multiplying an end-use savings percentage by the average consumption for the end use in a given building type (or plant type, depending on the sector). The model stores average consumption for each end use and building type, because it is intended to "roll up" to an accurate overall estimate of total gas consumption in the reference case. This average reflects a mix of efficiencies, including standard technologies, old equipment with efficiencies below standard market practice, and an assumed reference penetration for efficiency measures. The savings percentage estimate for an efficiency measure, however, is typically developed based on improving an end use that has the standard (relatively inefficient) technology, not the average. As a result, multiplying that percentage by the average consumption tends to

[37] Although Union Gas provided a high-level total reference case consumption for the entire study period, Union Gas only forecasts for three years (i.e. 2016-2018 in this case). As such, the consumption for the remaining years is based on an extrapolation of the near-term forecast.

underestimate the savings. This effect grows as the reference case penetration for the efficiency measure gets larger. ICF has made adjustments to correct for this effect.

2.6.3 Assumptions

Measures that are normally replaced at end of life, due mostly to economic considerations, are adopted at that rate, rather than assuming accelerated implementation. Measures that are not limited by equipment life are assumed to be adopted immediately.

When developing the technical potential, the baseline market penetration of measures is used to account for natural changes in gas consumption, based on the natural replacement of equipment and expected performance of new equipment. For example, in the absence of energy efficiency programs, which forms the backbone of the reference case, it is assumed that standard efficiency boilers will be replaced at the rate of natural replacement and that some of the boilers will be replaced with condensing boilers.

2.7 Economic Potential

The economic screen that was used in the economic potential scenario was the TRC-plus[38] cost effectiveness test, as was described in section 2.3.

By comparing the results of the economic potential with the reference case, it is possible to determine the aggregate level of potential natural gas savings, as well as identify which specific building segments, end uses and technologies can provide the most significant opportunities for savings.

To develop the economic potential forecast, the following tasks were completed:

- The measure TRC-plus results for each of the energy-efficiency measures were reviewed. The TRC-plus test for each measure was re-run using avoided cost streams beginning in each year of the study period.
- Technology upgrades that had positive (i.e. a greater than 1.0 benefit/cost ratio) measure TRC-plus results were selected for inclusion either on a “full-cost” or “incremental” basis.
- Technical upgrades passing the measure TRC-plus test on a full-cost basis were implemented in the first year of the economic potential in which they passed the TRC-plus test. Those upgrades that only passed the measure TRC-plus test on an incremental basis were introduced, beginning in the first year in which they passed the TRC-plus, as the existing stock reached the end of its useful life. If more than one cost-effective measure existed for the same end-use application, the study selected the most energy-efficient one.
- Energy use within each of the sub-sectors was modelled with the same energy models and general assumptions that were used to generate the reference case. However, for the economic potential, the remaining standard efficiency technologies included in the Reference Case were replaced with the most efficient technology upgrade option that passed the measure TRC-plus test.

[38] The TRC-plus test includes a 15% adder that accounts for the non-energy benefits associated with DSM programs, such as environmental, economic and social benefits, as selected by the OEB in 2015-2020 DSM Framework. It is aligned with the cost effectiveness test used by the IESO, as per the Minister of Energy's Conservation First Framework. Please refer to the glossary in Appendix A for a full definition of TRC-plus

2.7.1 Assumptions

The stream of future savings and costs is discounted using a real discount rate of 4%. Inflation is omitted from the analysis through the use of savings and costs that are expressed in constant 2014 dollars and a real discount rate.

Measures with a TRC-plus ratio greater than 1.0 are assumed to be implemented beginning in the year in which they become economic. A lower hurdle rate of a TRC-plus ratio of 0.7 was used for measures affecting the low-income customer segments.

2.8 Achievable Potential

Achievable Potential is defined as the portion of the economic conservation potential that takes into account realistic market penetration rates of cost-effective measures over the study period based on the following factors:

- Market barriers
- Customer preferences
- Incentive levels
- Aggressiveness of marketing efforts
- Historic program experience
- Competing DSM measures
- Increased collaboration between the natural gas and electric utilities
- Experience in leading jurisdictions
- Other factors

Three achievable potential scenarios were modeled as part of this study:

- **Unconstrained achievable potential:** Natural gas savings achieved through efficiency improvements resulting from the most aggressive DSM programs, assuming no budget constraints or policy restrictions over the study period
- **Constrained achievable potential:** Natural gas savings achieved through efficiency improvements resulting from programs at the DSM budget levels established by the OEB's Decision on the utilities' 2015-2020 DSM Plans over the study period
- **Semi-constrained achievable potential:** Natural gas savings achieved through efficiency improvements resulting from programs at DSM budget levels established by the OEB's Decision on the DSM Plans until 2017, then gradually increasing through 2018 and 2019 to twice the 2016 budget by 2020, and then staying at that level until 2030

It should be emphasized that the estimation of Achievable Potential is not synonymous with either the setting of specific program targets or with program design. While both are closely linked to the discussion of Achievable Potential, they involve more detailed analysis that is beyond the scope of this study.

2.8.1 Program Cases and Supply Curves

The constrained and semi-constrained scenarios for each sector were constructed based on conservation supply curves. In order to construct the conservation supply curves, it was necessary to estimate two program cases for each measure:

- **Business-as-usual (BAU) case:** A BAU program case with lower participation and assumptions of program activity and/or incentives (incentive levels similar to current incentive levels)
- **Aggressive case:** An aggressive program case with best-case participation and high assumptions of program activity and/or incentives (incentives levels that would be required for the customer to implement the measure)

Participation rates for these two cases were estimated based on consultations with market actors, which are described in more detail in each of the sector specific chapters.

These program cases were defined at the measure level (or for a basket of similar measures that would fit in one program), not at the achievable potential scenario level. All of the aggressive cases for the measures add up to unconstrained Achievable Scenario, because they represent the greatest achievable potential for each measure without budgetary limitations. Adding up all the BAU cases for the measures does not correspond to either of the other scenarios. That is because the optimal collection of programs that would achieve the most savings within a fixed budget tends to include a mixture of the aggressive cases of some inexpensive measures and the BAU cases of more expensive measures.

A conservation supply curve was constructed with natural gas savings on the horizontal axis and program cost on the vertical. Both program versions of each measure were included in the curve, sorted in order of increasing cost per unit of gas savings.[39] Gas savings for each budgetary level for the constrained and semi-constrained scenarios could then be found by drawing a horizontal line at that level to where it strikes the curve. The measures listed in the curve below the budget threshold line formed the collection of programs for a given scenario.

2.8.2 Interviews with Market Actors

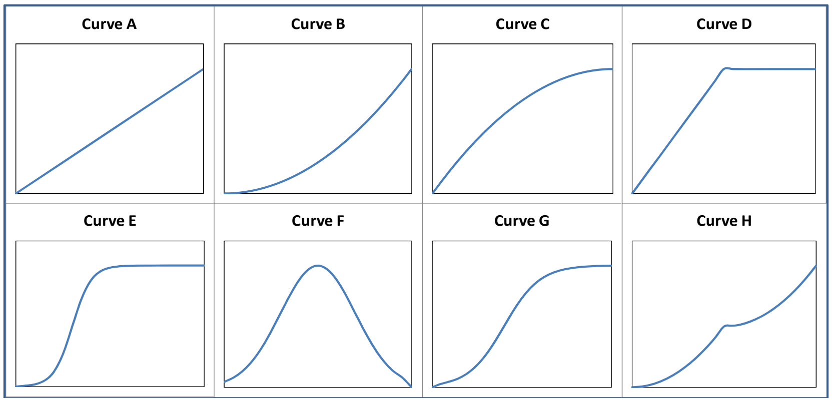
Interviews with market actors were performed for each sector to inform the participation rates and corresponding incentive levels required for the achievable potential analysis. Interviewees included best in class program administrators, utility staff, technical experts, and equipment suppliers. In advance of these interviews, the ICF team selected a number of representative measures for each sector, which represented a substantial fraction of the overall economic potential and several different energy end uses.

Interviewees were asked to consider two program scenarios for the measure – an aggressive program with everything “done right” (aggressive) and a “business as usual” (BAU) program more typical of past utility activity. In each case, ICF discussed what features the program might have, whether incentives would be important and at what level, what payback period would be required, and what other program support would be needed.

Interviewees were then asked to estimate the participation rates that could be achieved by 2030 for the aggressive and BAU program cases and to select one of several implementation curves, as shown in Exhibit 3, to indicate which adoption path the measure might follow between 2015 and 2030. For measures where several interviews were conducted, the curve that was ultimately used was the one that was selected the most often and with stronger justifications.

[39] The two versions of the program for each measure included in the curve represent, respectively, the costs and savings of the BAU version of the measure, and the costs and savings of the increment between BAU and aggressive versions of the measures. Thus, to obtain the costs and savings of the aggressive version of the measure, the two curve segments must be added together.

Exhibit 3 Sample Measure Implementation Curves



Interviewees were also asked to comment on how the participation rates of the remaining measures would compare to related representative measures. The results were aggregated and applied to the remaining measures. Participation rates were also compared to those of past utility DSM programs in order to check the participation assumptions.

2.8.3 Program Costs

The program costs for both the BAU case and the aggressive case include both incentive and non-incentive costs. Incentive costs were calculated based on current incentive levels and consultations with interviewees, the technical working group, and the utilities on the estimated level of incentive required to influence the adoption of a measure. These estimates are described for each sector in the sector-specific chapters.

Non-incentive costs are those costs associated with delivering the program, such as for marketing, program staff, etc. These costs were also estimated in consultation with interviewees, the technical working group, the utilities, and using assumptions about non-incentive to incentive program cost ratios, which are described for each sector in the sector-specific chapters. Non-incentive costs can include any other costs required in order to administrate a program, for example marketing and salary costs.

For measures with no capital cost, such as behavior measures, ICF assumed no incentive costs, but non-incentive program spending would still be required. ICF based the non-incentive cost estimate in these cases on the discounted value of the measure's savings. An estimated ratio of program cost to savings value was developed based on typical gas utility programs and was multiplied by the discounted savings value to provide an estimated program cost for the measure.

An estimate of the program costs for the BAU and aggressive program versions of each measure were required in order to:

- Estimate the cost of the unconstrained scenario
- Determine which measures could be included in the constrained and semi-constrained scenarios.

The methodology for estimating these program costs for each sector are provided in the sector-specific chapters.

2.8.4 Program Budgets

Program budgets were estimated for the following achievable potential scenarios:

- **Unconstrained scenario:** In the unconstrained scenario there are no budgetary limitations on program activities.
- **Semi-constrained scenario:** The 2015-2020 Semi-constrained budget was derived from actual spend from both utility's 2015 program year, plus the 2016 and 2017 budgets from the DSM Decision. The 2018 to 2020 budgets reflect a gradual increase in spending so that 2020 budgets are twice the value of the 2016 budgets.[40] The annual budgets for the period 2021-2030 are the same as the 2020 budget. A summary of the semi-constrained program budgets is provided in Exhibit 4.

Exhibit 4 Semi-Constrained Program Budgets from 2015 to 2030

Years	Semi-Constrained Program Budgets ($ million)									
	Residential Sector			Commercial Sector			Industrial Sector			All Sectors Total
	Non-Low-Income	Single-Family Low Income	All Residential	Non-Low-Income	Multi-Family Low Income	All Commercial	Non Large Volume	Large Volume	All Industrial	
2015-2020	$318	$148	$465	$214	$77	$292	$155	$34	$189	$946
2021-2030	$844	$388	$1,232	$571	$207	$778	$413	$86	$499	$2,509
Total	$1,161	$536	$1,697	$785	$285	$1,070	$568	$120	$688	$3,455

- **Constrained scenario:** The 2015-2020 constrained budget was derived from actual spend from Enbridge Gas Distribution and Union Gas' 2015 program year, plus the 2016-2020 DSM budgets from the DSM Decision.[41] The annual budgets for the period 2021-2030 are assumed to be the same as the 2016 annual budgets.[42] A summary of the constrained program budgets is provided in Exhibit 5.

Exhibit 5 Constrained Program Budgets from 2015 to 2030

Years	Constrained Program Budgets ($ million)									
	Residential Sector			Commercial Sector			Industrial Sector			All Sectors Total
	Non-Low-Income	Single-Family Low Income	All Residential	Non-Low-Income	Multi-Family Low Income	All Commercial	Non Large Volume	Large Volume	All Industrial	
2015-2020	$235	$108	$343	$157	$57	$214	$113	$24	$138	$695
2021-2030	$422	$194	$616	$286	$104	$389	$207	$43	$250	$1,255
Total	$657	$302	$959	$442	$161	$603	$320	$67	$387	$1,949

Both utilities provided combined commercial and industrial program budgets, so these commercial and industrial program budgets were split by ICF based on relative 2014 gas consumption amounts. Union Gas did not provide separate budgets for low-income residential and multi-family programs in 2015, so the low-income budget was apportioned according to the relative size of those two programs in 2016-2020. In both the constrained and semi-constrained scenarios budgets, overhead

[40] This approach was developed based on the OEB Request for Proposal (RFP).

[41] Ontario Energy Board 2015-2020 DSM decision, http://www.ontarioenergyboard.ca/OEB/Industry/Regulatory+Proceedings/Decisions

[42] Since the length of the 2021-2030 period is twice that of the 2016-2020 period, this is equivalent to maintaining the average annual budget at the same level for the 2021-2030 period.

was distributed according to what proportion the program made up of the total program budget. A detailed breakdown of both program budgets is provided in Appendix D.

2.8.5 Unconstrained Potential

All measures in the economic potential for which the ratio of the present value of the stream of savings (including gas, water, and electricity savings) to the value of the incentive was greater than or equal to 1.0 (or 0.7 for low-income programs) were included in the unconstrained potential scenario[43]. These ratios were selected in consultation with the technical working group and are not related to the TRC-plus ratios used in cost effectiveness screening.

For example, if the estimated value of the incentives was greater than the value of the gas savings, the measure was not included in the unconstrained scenario. Conversely, if the value of the incentive was found to be less than the value of the savings for both program cases, the aggressive case was included in the unconstrained scenario. If the ratio for the BAU case passed this test, but the aggressive case did not, the BAU case was included, plus a portion of the aggressive case so that the ratio of incentive to savings value was approximately 1.0 (or 0.7 for low-income programs).

2.8.6 Constrained and Semi-Constrained Potential

In the constrained and semi-constrained potentials, the mix of included measures was optimized in 2020 and again in 2030 so that the maximum amount of savings could be included up to the given program budget in each of these time frames. The constrained and semi-constrained scenarios for each sector were constructed based on supply curves, with life cycle savings of all measures implemented on the x-axis and total program spending to obtain them on the y-axis. Measures were sorted in increasing order of program spending per unit of savings. The BAU case of the measure and the increment between the BAU and aggressive cases were considered to be separate steps in the curves.

These supply curves were used to decide which measures would be included in each achievable potential scenario. All measure versions that are within the part of the curve before the target budget cut-off were included. Measures above this point were excluded, and measures that straddled the boundary were partially included. Because measures are sorted in increasing order of cost per unit of savings, this causes the model to produce the largest amount of savings for the given budget.

The steps for developing both the constrained and semi-constrained potentials were the same, but with different budget limitations. The steps for low-income building segments within the residential and commercial sectors were also the same, and for the large volume segments in the industrial sector, but with separate budgets.

2.8.7 Optimization

The unconstrained potential scenario did not require optimization, because there was no budget constraint limiting the program options that may be included. All of the aggressive versions of program options for the measures were included, to the extent that the incentives offered were not greater than the net present value of the gas savings.

The ICF models treat a given BAU or aggressive program case for a measure as having a constant program cost per unit of savings obtained. The optimization process consisted of ordering the individual measure options by program cost per unit of savings and including all of the lowest cost measure options until the overall achievable scenario budget was exhausted. The optimization

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[43] This test differs from the Program Administrator Cost (PAC) test in that only incentive values were considered, not all costs incurred by the program administrator. The PAC test is used to measure the net costs of a program based on the costs incurred by the program administrator, including incentives, marketing budgets, salaries, and excluding any costs incurred by the participant.

process also involved determining the portion of the measure at the budget margin that should be included.

Including more than two program cases per measure would offer a greater level of granularity, in terms of how much program activity is appropriate for a given measure. The overall level of savings for a given sector within the constrained or semi-constrained scenario would be unlikely to change dramatically, but there would be a refinement in which measures and program options are included in the optimized scenario. This enhancement could be undertaken in follow-on work, or as part of detailed program planning by the utilities.

2.9 GHG Emission Reductions

The GHG emission reductions for all three sectors were calculated using an emission factor of 1.863 kg CO_2/m^3.[44]

2.10 Sensitivity Analysis

In order to analyze the effect of changes to critical variables included within the potential study, ICF altered the avoided cost and participation rates and examined the impacts to the conservation potential results, as described below.

2.10.1 Avoided Cost

The avoided costs were increased by 50% and new model results were generated. This higher avoided cost scenario was chosen to account for the possibility of higher commodity prices, natural gas price suppression effects, and a price on carbon in the future. This change increased the number of measures that passed the TRC-plus test and therefore affected the economic and achievable scenarios.

2.10.2 Participation Rates

The participation rates for all measures were increased to explore the effect of different levels of program success at a given level of program support. A combination of the following two approaches were used to alter the participation rates by 20%.

- **Multiplicative:** Every 2030 participation was multiplied by 1.2. If 2030 participation was originally 10%, it became 12%. If it was originally 70%, it became 84%. This approach had a similar effect across all measures, but it had to be limited to prevent participation from exceeding 100%.
- **Portion of Remainder:** 20% of the remaining opportunity was added to the original participation. If 2030 participation was originally 10%, it became 28%[45]. If it was originally 70%, it became 76%[46]. This approach would never result in a participation that exceeds 100%, but it does not affect all measures in a similar fashion, as one measure’s participation was nearly tripled and the other increased only moderately.

For the sensitivity analysis, the lesser of the results of the multiplicative and portion of remainder approach was used. The combination of the approaches ensured that participation never exceeded 100% and the size of the effects would be comparable. Since participation rates are not considered until the achievable potential, this change does not affect the technical or economic potential.

[44] The Guideline for Greenhouse Gas Emissions Reporting December 2015, Ministry of the Environment and Climate Change recommends an emission factor of 1.863 kg CO_2/m^3 for natural gas in Ontario. http://www.downloads.ene.gov.on.ca/envision/env_reg/er/documents/2015/012-4549_d_Guideline.pdf

[45] 10% + 20%*(100%-10%) = 28%

[46] 70% + 20%*(100%-70%) = 76%

3 Avoided Costs

3.1 Introduction

Avoided costs are one of the key components of the cost-effectiveness tests that are used to evaluate energy efficiency investments. Cost-effectiveness represents whether an investment's benefits exceed its cost. This chapter documents the calculation of the natural gas avoided costs used by ICF to evaluate the cost effectiveness of natural gas conservation measures in Ontario.

The avoided cost analysis consists of two major elements. The first is an assessment of avoided gas utility costs, including avoided natural gas commodity costs, pipeline costs, storage, and facilities costs. The second is an estimate of avoided non-energy costs.

ICF evaluated avoided cost studies submitted to the OEB by the utilities, as well as studies filed by intervenors, and other sources of avoided cost information and data. The research was then applied to ICF's natural gas market outlook for Ontario in order to develop the avoided natural gas cost inputs needed for the conservation potential study.

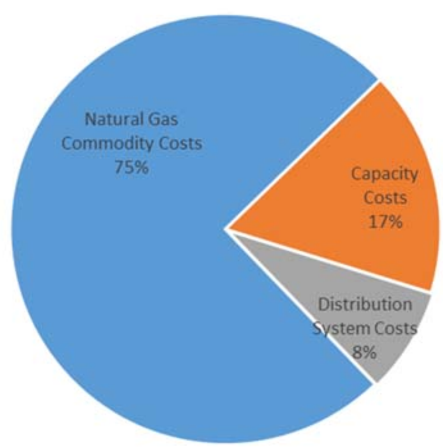
3.2 Natural Gas Distribution Company Avoided Costs

The natural gas avoided costs used in the conservation potential study include the direct natural gas supply and infrastructure costs that can be avoided by the utilities as a result of a decrease in demand, resulting from a reduction in load attributed to the conservation program, as well as other avoided costs not paid directly by the utilities.

These costs fall into the following categories, as shown in Exhibit 5:

- **Natural Gas Commodity Costs:** (about 75% of total avoided utility costs between 2016 and 2018) are what it costs the utility to buy the natural gas, but does not account for other components of energy cost, such as transportation, storage, and distribution costs.
- **Upstream Capacity Costs:** (Pipelines and Storage costs upstream of the utility citygate – about 17% of total avoided natural gas costs between 2016 and 2018). Avoided capacity costs represent the savings associated with a reduction in upstream pipeline transportation and gas storage requirements associated with a reduction in demand. Capacity costs that can be avoided depend on the characteristics of a gas distributor's existing gas supply portfolio, and the opportunities to add or reduce capacity in response to changes in demand. Both Union Gas and Enbridge Gas Distribution rely on natural gas storage to reduce delivered natural gas costs and to provide supply reliability. Both utilities own significant storage capacity located in the Dawn area that is reserved to serve in-franchise weather sensitive demand requirements, such as space heating. Weather sensitive load typically uses storage capacity to allow year round purchases of natural gas to meet demand that peaks in the winter, minimizing the need to hold pipeline capacity that would not be fully utilized during the summer months. Weather sensitive conservation measures can have a relatively significant impact on the required levels of storage capacity.

Exhibit 6 Natural Gas Distribution Company Avoided Costs



- **Downstream Distribution System Costs:** (Transmission, storage, and distribution system downstream of the utility citygate – about 8% of total avoided natural gas costs between 2016 and 2018) represents the cost of storing and delivering the gas on the utilities' distribution system. Most distribution system costs are related to the development and maintenance of the utility distribution systems, and are dependent on the number of customers connected to the system rather than throughput volume. As a result, most of the costs associated with the existing distribution system are not avoidable. Potentially avoidable facility costs are geographically specific and include the capital and financing costs planned for future transmission and distribution system expansions or reinforcements where demand is forecasted to grow over time beyond current system capacity threshold that could be delayed, reduced, or avoided at lower levels of demand.

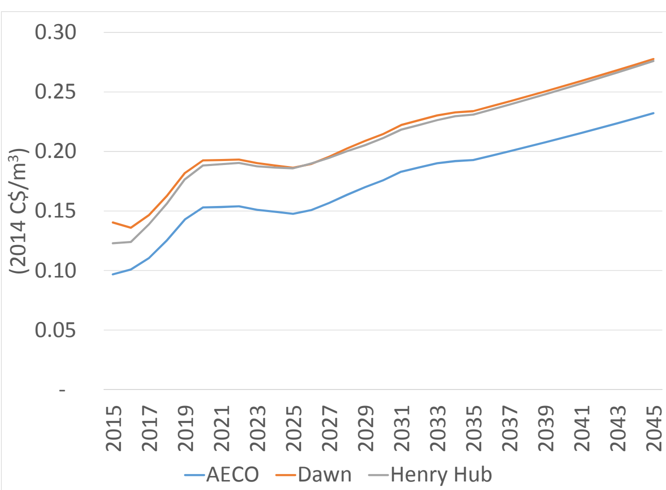
Natural gas commodity costs and capacity costs make up the gas supply costs upstream of the citygate and distribution system costs account for the delivered gas supply costs downstream of the citygate.

3.2.1 Avoided Natural Gas Commodity Costs

The single largest determinant of natural gas avoided cost for distribution companies is the commodity price of natural gas. ICF used Union Gas and Enbridge Gas Distribution SENDOUT© forecasts of delivered commodity prices, escalated based on the change in natural gas prices from the ICF January 2016 Base Case Natural Gas Market Outlook for natural gas prices through 2035.

The escalation rate was applied only to the commodity portion of the delivered gas price, based on a weighted average of supply basin prices. The ICF gas price forecasts for Dawn, AECO, and Henry Hub used in the estimation of Ontario avoided costs are shown in Exhibit 7. The natural gas prices at AECO and at Dawn are the most important drivers of Ontario avoided natural gas costs. However, the prices at these points are closely linked to the broader North American natural gas market.

Exhibit 7 ICF Natural Gas Commodity Price Forecast

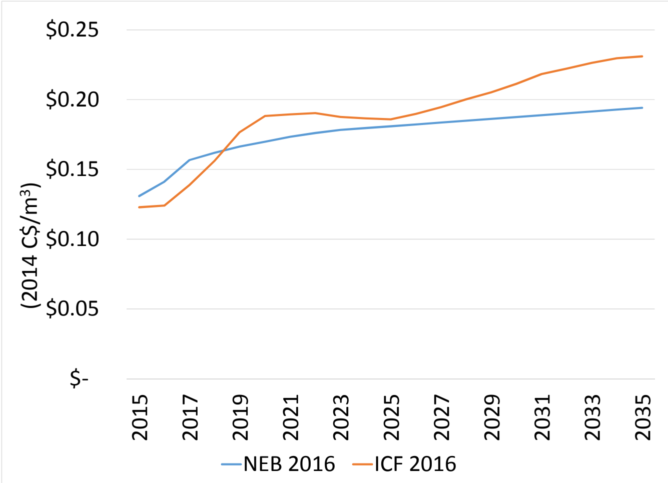


Prices at Henry Hub are the most widely accepted indicator for natural gas prices in the broader North American market. Changes in the North American market related to the growth in natural gas production from the Marcellus and Utica in the Northeastern U.S., as well as growth in exports to Mexico, LNG exports from the U.S. Gulf Coast, and growth in U.S. power generation demand in the Southeastern U.S. are projected to lead to faster increases in natural gas prices at Henry Hub than at Dawn.

The difference between the AECO price and the Dawn price reflects the value of transportation between the two points, and reflects general market conditions in the two markets, as well as tolls on the TransCanada Pipeline and other pipelines that connect the two markets. ICF is projecting a continuation of existing tolling practices on these pipelines, including the impacts of the TransCanada Energy East and Eastern Mainline Expansion projects.

The Ontario avoided costs reflects a modest near term rebound in North American natural gas prices in 2016 and 2017, followed by an increase in prices from around US$3.00 per MMBtu in 2017 to about US$4.30 by 2021 due to rapid growth in natural gas demand associated with growing LNG exports and exports to Mexico as well as growth in power generation demand.

Exhibit 8 Comparison of ICF and NEB Natural Gas Price Forecast at Henry Hub



As shown in Exhibit 8, the ICF natural gas commodity price forecast for Henry Hub is similar to, although slightly higher than, the reference case Henry Hub price forecast published in the NEB report "Canada's Energy Future 2016".[47]

For the period from 2035 to 2045, ICF escalated commodity prices at the average compound growth rate over the 2030 to 2035 period, about 1.9% per year in real terms, or 4% per year in nominal (inflation adjusted) dollars. For conservation programs with impacts after 2045, commodity prices are held constant in real terms at 2045 prices.

3.2.2 Avoided Capacity Costs

Both Union Gas and Enbridge Gas Distribution rely on a portfolio of different supply options with different costs in order to provide supply diversity, the avoidable capacity costs typically are not determined solely by the most expensive supply option. Over the long term, a reduction in demand likely will result in a relatively proportionate reduction in all of the different supply options, rather than the elimination of the most expensive supply option. In addition, commodity costs for different supply options are often inversely related with capacity costs of the option, hence avoided commodity costs and avoided capacity costs must be considered together; and an increase in capacity costs is often offset by a decrease in commodity costs.

3.2.3 Avoided Distribution System Costs

ICF has categorized all avoidable utility costs downstream of the citygate as avoided distribution system costs. These include avoided distribution facility costs, avoided storage costs downstream of the utility citygate, and other avoidable variable costs.

Avoided Distribution System Facility Costs

Only Enbridge Gas Distribution has filed an avoided distribution cost study. This distribution cost study was prepared for Enbridge Gas Distribution by Navigant Consulting and was included in its 2016-2020 DSM Plan. More recently, Navigant completed an update to the distribution cost study in December 2015, correcting certain omissions and updating values to reflect more current information. Union Gas has not independently estimated avoided distribution system costs. Instead, Union Gas has relied on an adjusted version of the Enbridge Gas Distribution values, until it completes its own study.

For this project, ICF relied primarily on the estimate of avoidable distribution system costs provided by Enbridge Gas Distribution in January of 2016 and prepared by Navigant Consulting. The Navigant study provided an estimate of avoided distribution system costs for each year from 2016 through 2032. ICF used the values from the Navigant study through 2032 for both Enbridge Gas Distribution and Union Gas. In order to extend this estimate through 2045 for this study, ICF used the levelized

[47] Government of Canada: National Energy Board, "Canada's Energy Future 2016: Energy Supply and Demand Projections to 2040," Accessed June 29, 2016, http://www.neb-one.gc.ca/nrg/ntgrtd/ftr/2016/index-eng.html.

value of the Navigant study from 2016 through 2032, for each year from 2033 through 2045, adjusting the value in each year for inflation.

Some other parties to the 2016-2020 DSM Plan proceeding have criticized the Navigant study, and have suggested that the study potentially understates actual avoidable facility costs. However, no other Ontario-specific analysis of avoidable distribution systems costs is currently available, and ICF has chosen to adopt the Enbridge Gas Distribution estimates due to the lack of alternative estimates.

Avoided Storage Costs in Avoided Distribution System Costs

Union Gas and Enbridge Gas Distribution differ in the treatment of avoidable storage costs due to differences in the structure of the utilities' systems. Union Gas utilizes natural gas storage capacity it owns downstream of the Union Gas citygate at Dawn to serve in-franchise load. Enbridge Gas Distribution storage capacity is located upstream of the Enbridge Gas Distribution citygate, and the costs of storage capacity are included in the Enbridge Gas Distribution SENDOUT analysis. Hence, Union Gas storage costs are included in the avoided distribution costs, while Enbridge Gas Distribution storage costs are included in the avoided gas supply costs.

Based on reported Union Gas load calculations, a DSM program targeting weather sensitive load will reduce the need for storage capacity by about 3 cubic metres for every 10 cubic metres of demand reduction. At an estimated storage cost of $0.0071 per cubic metre[48], any reduction in demand attributed to a weather sensitive DSM program would save $0.0016 per cubic metre. This cost represents about 0.7% of the total estimated avoided cost for a weather sensitive DSM program. ICF has used the Union Gas estimates of avoided storage costs in the estimation of Union Gas system share of the Ontario avoided costs. Since Enbridge Gas Distribution considers storage in citygate costs, no adjustments for Enbridge Gas Distribution were needed.

Other Avoided Distribution System Costs

Union Gas includes a variable distribution system cost of 0.153% of in-franchise system throughput in its calculation of avoided costs, reflecting natural gas system losses and fuel consumption. Enbridge Gas Distribution does not appear to have included an estimate of variable distribution system costs in its avoided costs. ICF has used the Union Gas estimate of variable distribution system costs for both Union Gas and Enbridge Gas Distribution avoided costs.

3.2.4 Methodology Estimation of Utility Natural Gas Avoided Costs

General Approach

ICF has not attempted to independently estimate Ontario avoided natural gas costs. Instead, ICF has used utility estimates of the different components of avoided natural gas costs, updated the utility estimates to reflect current market conditions where appropriate, adjusted the utility estimates where appropriate, and projected the utility estimates through the time period of the analysis.

For the purposes of estimating avoided costs, both Union Gas and Enbridge Gas Distribution divide the direct utility costs into the gas supply costs incurred upstream of the utility citygate[49], and the distribution system costs incurred downstream of the citygate. The gas supply costs upstream of the citygate include natural gas commodity costs and pipeline transportation costs, including capacity costs on upstream pipelines (capacity costs). Enbridge Gas Distribution also includes natural gas storage costs, which are incurred upstream of the Enbridge Gas Distribution citygate, in its estimates of avoided gas supply costs.

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[48] Union Gas Limited. (2013). Rebasing Application Rate Order - Appendix B. Storage Charge from Rate M1 Rate Schedule: EB-2011-0210.

[49] Distribution system connection point where natural gas pressure is reduced to a rate appropriate for consumer usage.

Gas distribution system costs include infrastructure and operating costs incurred as part of the utility's system downstream of the citygate. These costs can include the costs of both transmission and distribution systems used to serve utility customers within the utility service territory. Functionally, Union Gas treats the costs associated with the storage assets used by its distribution customers, which are generally located downstream of the Union Gas citygate, as distribution system costs rather than gas supply costs.

Gas Supply Costs Upstream of the Utility Citygate

Both utilities use the SENDOUT© supply planning model to estimate avoided gas supply costs upstream of the utility citygate. The SENDOUT© model is an industry standard natural gas supply portfolio model, and is widely used in supply planning and avoided cost estimation throughout the natural gas industry.

In the simplest of terms, the utilities use the SENDOUT© model to determine total gas supply costs required to meet the utilities' forecast of natural gas demand under two different demand scenarios. The two demand scenarios include:

- A Base Case forecast of natural gas demand, which considers the impacts of a portfolio of DSM programs.
- A forecast of natural gas demand excluding the impacts of a portfolio of DSM programs.

The utilities then use the difference in supply costs between the two scenarios to estimate avoided gas supply costs. The utilities run different "No DSM" scenarios that change the portfolio of DSM programs removed from the demand forecast in order to estimate avoided gas costs for DSM programs targeting different types of load. The difference between the total supply costs with and without the DSM program impacts are used to calculate the total avoided cost associated with the change in demand caused be the specific set of DSM programs being evaluated. For example, removing the impacts of a specific set of DSM programs may increase demand by 50 million cubic metres and increase supply costs by $10 million. In this case, the avoided cost would be $0.20 per cubic metre.

The SENDOUT© model analysis considers the commodity cost of natural gas as well as incremental cost of upstream pipeline and storage capacity. Hence, the SENDOUT© model analysis results reflect avoidable commodity costs as well as avoidable upstream capacity costs.

Both utilities use a forecast of monthly commodity prices for each potential supply source as an input to the SENDOUT© model analysis. The SENDOUT© model chooses the least cost mix of commodity purchases, consistent with pipeline capacity constraints when determining the optimal supply mix for each demand scenario. The reduction in demand associated with DSM programs leads to a reduction in purchases of the most expensive source of incremental supply. For the Northern and western regions of Ontario, this is generally purchases at Empress. For the Southern and eastern regions, this is generally citygate purchases at Dawn.

The pipeline capacity held by the utilities for each year of the DSM plan is determined by the underlying contracted upstream transportation portfolio in place at the time of the creation of the DSM avoided cost plan and is an input into the SENDOUT© model analysis used to estimate overall avoided costs.

The reference case used for avoided natural gas costs delivered to the utility city gate are derived directly from the most recent SENDOUT© analysis of avoided natural gas costs from Union Gas and Enbridge Gas Distribution, updated by ICF to reflect current market conditions and ICF's January 2016 long term commodity price projections. The Enbridge Gas Distribution analysis provides an estimate of annual citygate avoided costs for 2016 through 2019. The most recent available avoided cost analysis from Union Gas was filed in the 2016-2020 DSM Plan and includes an estimate of annual citygate avoided costs for 2016 through 2044.

For each utility, ICF separated the SENDOUT© citygate avoided costs into commodity costs and non-commodity costs based on information derived from each utility's avoided cost data, and ICF's forecast of commodity costs, and then separately forecast the commodity and non-commodity components of the avoided citygate costs for both utilities.

The most recent Enbridge Gas Distribution forecast of avoided costs was relatively contemporaneous with the ICF analysis, and no adjustments to the citygate price were determined to be necessary. ICF used the ICF forecast of commodity prices, weighted 80% at Dawn and 20% at AECO, to divide the Enbridge Gas Distribution avoided costs into commodity and non-commodity cost components for the 3-year period from 2016 through 2018.

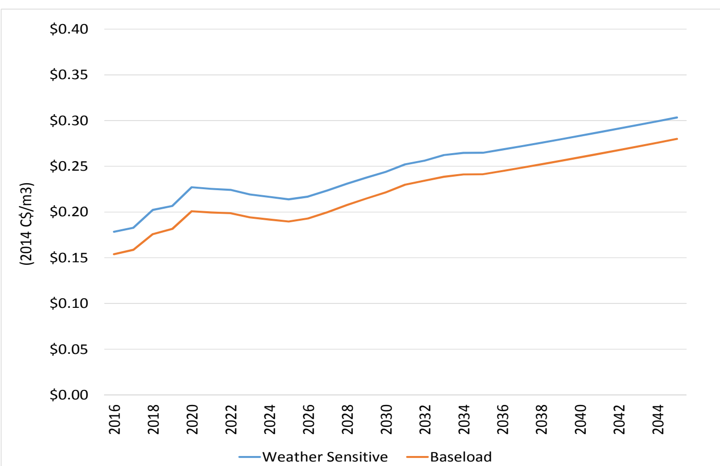
For Union Gas, ICF used the spreadsheet provided by Union Gas during the 2016-2020 DSM proceeding (the Union Gas Avoided Cost Calculator[50]) to divide the citygate avoided cost into commodity and non-commodity components for the three year period from 2016 through 2018.

The avoided commodity cost component of the citygate avoided cost forecast for both Union Gas and Enbridge Gas Distribution were developed based on the ICF 2016 January Base Case forecast, weighted 80% at Dawn and 20% at AECO for the period from 2016 through 2035. After 2035, the commodity costs were escalated at the average growth rate of the ICF forecast from 2030 through 2035, or about 1.9% per year (real), or 3.9% per year in nominal dollars for AECO, and about 1.7% per year (real), or 3.7% per year in nominal dollars for Dawn.

The non-commodity cost element of the citygate price was held constant in real terms throughout the forecast.

3.2.5 Aggregating Utility Data to Estimate Ontario Avoided Costs

Exhibit 9 Ontario Avoided Natural Gas System Costs



ICF used a weighted average of the updated Union Gas and Enbridge Gas Distribution avoided costs estimates. The utility specific avoided cost estimates were weighted based on the 2014 delivered distribution volume for the two utilities (53% Union Gas, 47% Enbridge Gas Distribution) from the 2014 Annual Report for each utility. ICF's estimates for avoided natural gas costs by load segment are shown in Exhibit 9. The data for each load segment is included at the end of this chapter, in Exhibit 11.

3.2.6 Aggregation by Load Segment

The Ontario avoided costs used in the ICF conservation potential study are more aggregated than the avoided cost estimates used by the utilities. ICF combined Enbridge Gas Distribution space heating load, and Union Gas residential/ commercial weather heating load data weighted by the distribution system volumes for the two companies to develop the avoided costs for the weather sensitive load category. For the baseload category, ICF used the average of Enbridge Gas

[50] EB-2015-0029, Exhibit B.T9.Union.GEC.21 part k

Distribution water heating load and industrial base load, and the average of Union Gas residential/commercial baseload and industrial baseload, weighted by the distribution system volumes for the two companies.

The two utilities have different supply strategies that result in modest differences in avoided system costs. Enbridge Gas Distribution's heating season costs typically are higher than Union Gas', as Enbridge Gas Distribution requires additional pipeline capacity downstream of the market center at Dawn relative to Union Gas. Differences in timing and market assumptions between the avoided cost estimates prepared by Union Gas and Enbridge Gas Distribution also impact the relative avoided costs of the two utilities.

3.3 Avoided Non-Energy Costs

The natural gas avoided costs used in the approved 2015-2020 DSM plans by the utilities included a 15 percent adder to account for the non-energy benefits associated with utility sponsored conservation programs. The 15 percent adder was specified in the OEB's 2015-2020 DSM Framework. In a letter dated October 23, 2014[51], the Ontario Minister of Energy directed the Ontario Power Authority[52] to include a 15 percent adder to the TRC-plus test to account for non-energy benefits associated with utility sponsored conservation programs.

The OEB determined that it would apply the same 15 percent adder when assessing Ontario utility conservation programs:

> "To effectively align natural gas DSM programs with electricity CDM programs and take into consideration government objectives outlined in the Conservation Directive to the OPA, the Board has concluded that the same approach should be used for screening DSM programs."[53]

In order to maintain consistency with the OEB's DSM Framework, ICF has included a 15 percent adder to the avoided cost to account for these benefits.

3.4 Assumptions

3.4.1 Avoided Cost Economic Parameters

The basic parameters and economic drivers of the avoided cost estimates, including analysis time frame, currency exchange rate, inflation rate, and discount rate are reviewed below:

- **Analysis Time Frame:** ICF has estimated avoided costs for 30 years, from 2016 through 2045 in order to capture the long term impacts of the DSM programs, and to allow the cost effectiveness of conservation measures to be estimated at different points in time. Through 2035, the avoided gas costs are based on ICF Q1 2016 Base Case gas market forecast. After 2035, the gas cost and natural gas price suppression effect components of the avoided cost are escalated at the average change in natural gas prices between 2030 and 2035 from the ICF Base Case forecast. The other cost elements, including distribution facility costs, which are projected by Enbridge Gas Distribution out through 2032, are held constant in real terms after the time frame of the forecast. For applications with a lifespan beyond 2045, the avoided costs are held constant in real terms at 2045 levels.

[51] Letter dated October 23, 2014, RE: Amending March 31, 2014 Direction regarding 2015-2020 Conservation First Framework, From Minister Bob Chiarelli to Mr. Colin Andersen, CEO Ontario Power Authority.

[52] Now the Independent Electricity System Operator (IESO)

[53] Page 33, EB-2014-0134, Report of the Ontario Energy Board, Demand Side Management Framework for Natural Gas Distributors (2015-2020), December 22, 2014.

- **Currency Exchange Rates:** Currency exchanges rates have a major impact on Ontario avoided costs. The price of natural gas purchased by Ontario utilities and end-users is largely set by the broader North American market, and prices are largely set in U.S. dollars. Hence, natural gas commodity prices in Ontario increase when the Canadian dollar falls relative to the U.S. dollar, and decrease when the Canadian dollar increases relative to the U.S. dollar. For this study, the value of the Canadian dollar has been set at USD$0.80, and held constant over the lifetime of the analysis, consistent with the long term exchange rate used in by the National Energy Board in the report “Canada’s Energy Future 2016”.[54]
- **Discount Rates:** Consistent with current OEB DSM Framework, ICF has used a real discount rate of 4.0% when evaluating long term avoided costs
- **Inflation Rate**: When expressed in nominal dollars, all of the avoided cost elements are escalated at 2.1% per year[55]

3.4.2 Avoided Cost Disaggregation

Natural gas avoided costs tend to differ somewhat based on utility, location, customer type and shape of the load impacts of the conservation program. As a result, costs are often estimated separately for residential, commercial, and industrial customers, since these sectors can have different load profiles. Avoided costs can also be calculated separately for different types of natural gas end-uses, as the load profiles for different types of equipment can also vary significantly. End-uses will typically be grouped according to whether their gas demand is relatively constant throughout the year (e.g., water, or other non-heating loads) or if demand changes throughout the year (e.g., space heating loads). The geographic and end-use disaggregation used in this study is described below.

Geographic Disaggregation

ICF has estimated an average avoided cost for all of Ontario rather than by utility distribution territory or region within Ontario. While certain regions within the province likely will have avoided costs that are higher or lower than the Ontario average, the differences are expected to even out for the province-wide review of conservation potential.

End-Use Disaggregation

Both Enbridge Gas Distribution and Union Gas estimate avoided costs independently for their service territories for their own DSM programs. ICF has estimated utility avoided costs for baseload and weather sensitive end use load profiles. While this approach is not as detailed as the level of disaggregation used by the utilities when developing their own DSM programs, the two load segments considered by ICF are sufficient to address the major implications of differences in load type on conservation potential in Ontario. The additional avoided cost categories used by both Union Gas and Enbridge Gas Distribution fall between the base load and weather sensitive load estimates in the ICF avoided cost study.

[54] “Canada’s Energy Future 2016: Energy Supply and Demand Projections to 2040”, page 37, National Energy Board.

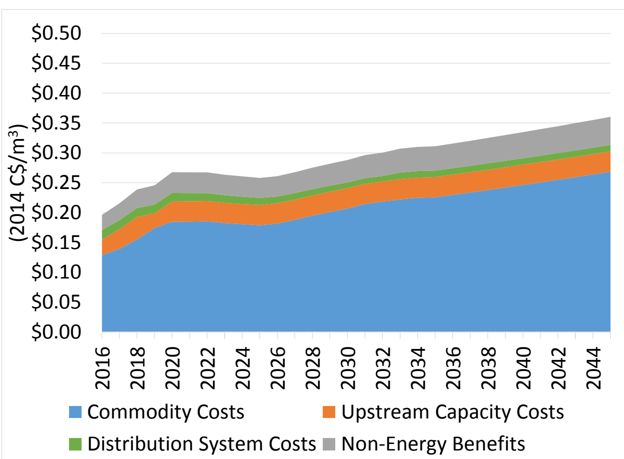
[55] An inflation rate of 2.1 % represents the typical long-term average inflation rate.

3.5 ICF Ontario Avoided Natural Gas Costs

The avoided natural gas costs used to assess the conservation potential in Ontario reflect the sum of the natural gas utility avoided costs (natural gas commodity costs, capacity costs and distribution system costs), plus a 15% adder to account for the value of non-energy benefits, including carbon reductions and other non-energy avoided costs. Exhibit 10 depicts the full avoided cost estimate used to evaluate the conservation potential of weather sensitive conservation measures (e.g., space heating), and baseload conservation measures (e.g., water heating). Exhibit 11 provides the results in tabular format, broken out by commodity cost, upstream capacity costs, distribution system costs, and non-energy benefits for weather sensitive and baseload conservation programs. ICF has used the same average commodity price forecast for both baseload and weather sensitive load, as the utility avoided cost estimates provided only citygate prices (commodity prices plus transportation and upstream storage costs). ICF expects actual commodity prices for baseload and weather sensitive load to vary slightly, although the utilization of storage to levelize purchases for weather sensitive load by both major Ontario utilities is expected to lead to very similar commodity cost profiles for both weather sensitive and baseload load profiles.

Ontario weather sensitive avoided costs applied to the study were $0.196/m^3 in 2016 and $0.360/m^3 in 2045. Ontario baseload avoided costs applied to the study were $0.172/m^3 in 2016 and $0.337/m^3 in 2045.

Exhibit 10 Avoided Costs for Weather Sensitive (left) and Baseload (right) Natural Gas Load in Ontario (2014 C$/m^3)



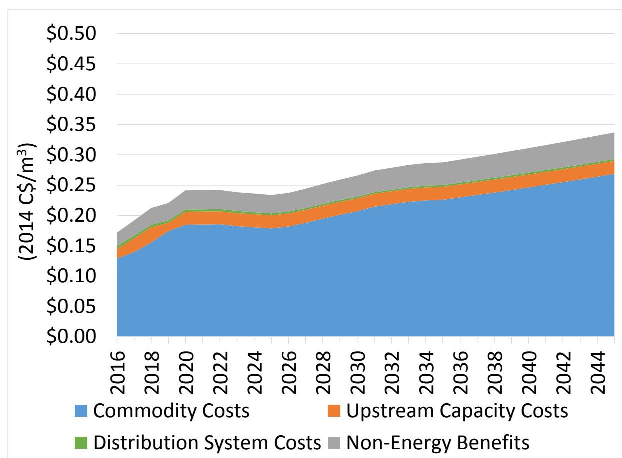


Exhibit 11 Avoided Costs for Weather Sensitive (left) and Baseload (right) Natural Gas load in Ontario (2014 C$/m^3)

Year	Commodity Costs	Upstream Capacity Costs	Delivered Gas Costs	Distribution System Costs	Utility Avoided Costs	Non-Energy Benefits	Total Avoided Costs
2016	$0.129	$0.026	$0.155	$0.016	**$0.171**	$0.026	**$0.196**
2017	$0.139	$0.033	$0.172	$0.015	**$0.188**	$0.028	**$0.216**
2018	$0.155	$0.037	$0.193	$0.015	**$0.208**	$0.031	**$0.239**
2019	$0.174	$0.025	$0.199	$0.015	**$0.214**	$0.032	**$0.246**
2020	$0.185	$0.034	$0.219	$0.014	**$0.233**	$0.035	**$0.268**
2021	$0.185	$0.034	$0.219	$0.014	**$0.233**	$0.035	**$0.267**
2022	$0.185	$0.034	$0.219	$0.013	**$0.233**	$0.035	**$0.267**
2023	$0.182	$0.034	$0.216	$0.013	**$0.229**	$0.034	**$0.263**
2024	$0.181	$0.034	$0.214	$0.012	**$0.227**	$0.034	**$0.261**
2025	$0.179	$0.034	$0.213	$0.012	**$0.224**	$0.034	**$0.258**
2026	$0.182	$0.034	$0.216	$0.011	**$0.227**	$0.034	**$0.261**
2027	$0.188	$0.034	$0.222	$0.011	**$0.233**	$0.035	**$0.268**
2028	$0.195	$0.034	$0.229	$0.011	**$0.239**	$0.036	**$0.275**
2029	$0.201	$0.034	$0.235	$0.010	**$0.245**	$0.037	**$0.282**
2030	$0.207	$0.034	$0.241	$0.010	**$0.251**	$0.038	**$0.288**
2031	$0.214	$0.034	$0.248	$0.009	**$0.258**	$0.039	**$0.296**
2032	$0.218	$0.034	$0.252	$0.009	**$0.261**	$0.039	**$0.300**
2033	$0.222	$0.034	$0.256	$0.011	**$0.267**	$0.040	**$0.307**
2034	$0.225	$0.034	$0.259	$0.011	**$0.269**	$0.040	**$0.310**
2035	$0.226	$0.034	$0.260	$0.011	**$0.270**	$0.041	**$0.311**
2036	$0.230	$0.034	$0.264	$0.011	**$0.274**	$0.041	**$0.316**
2037	$0.234	$0.034	$0.268	$0.011	**$0.278**	$0.042	**$0.320**
2038	$0.238	$0.034	$0.272	$0.011	**$0.283**	$0.042	**$0.325**
2039	$0.242	$0.034	$0.276	$0.011	**$0.287**	$0.043	**$0.330**
2040	$0.246	$0.034	$0.280	$0.011	**$0.291**	$0.044	**$0.335**
2041	$0.250	$0.034	$0.284	$0.011	**$0.295**	$0.044	**$0.340**
2042	$0.255	$0.034	$0.289	$0.011	**$0.300**	$0.045	**$0.345**
2043	$0.259	$0.034	$0.293	$0.011	**$0.304**	$0.046	**$0.350**
2044	$0.264	$0.034	$0.298	$0.011	**$0.309**	$0.046	**$0.355**
2045	$0.269	$0.034	$0.302	$0.011	**$0.313**	$0.047	**$0.360**
Net Present Value (4% Real Discount Rate)							
2016-2020	$0.691	$0.138	$0.829	$0.067	**$0.896**	$0.134	**$1.031**
2016-2030	$1.943	$0.364	$2.307	$0.146	**$2.452**	$0.368	**$2.820**
2016-2045	$3.404	$0.574	$3.977	$0.211	**$4.188**	$0.628	**$4.816**

Year	Commodity Costs	Upstream Capacity Costs	Delivered Gas Costs	Distribution System Costs	Utility Avoided Costs	Non-Energy Benefits	Total Avoided Costs
2016	$0.129	$0.016	$0.145	$0.005	**$0.149**	$0.022	**$0.172**
2017	$0.139	$0.023	$0.163	$0.004	**$0.167**	$0.025	**$0.192**
2018	$0.155	$0.025	$0.181	$0.004	**$0.185**	$0.028	**$0.212**
2019	$0.174	$0.014	$0.188	$0.004	**$0.192**	$0.029	**$0.221**
2020	$0.185	$0.021	$0.206	$0.004	**$0.210**	$0.031	**$0.241**
2021	$0.185	$0.021	$0.206	$0.004	**$0.210**	$0.032	**$0.242**
2022	$0.185	$0.021	$0.207	$0.004	**$0.210**	$0.032	**$0.242**
2023	$0.182	$0.021	$0.204	$0.003	**$0.207**	$0.031	**$0.238**
2024	$0.181	$0.021	$0.202	$0.003	**$0.205**	$0.031	**$0.236**
2025	$0.179	$0.021	$0.200	$0.003	**$0.203**	$0.030	**$0.234**
2026	$0.182	$0.021	$0.203	$0.003	**$0.206**	$0.031	**$0.237**
2027	$0.188	$0.021	$0.209	$0.003	**$0.212**	$0.032	**$0.244**
2028	$0.195	$0.021	$0.216	$0.003	**$0.219**	$0.033	**$0.252**
2029	$0.201	$0.021	$0.222	$0.003	**$0.225**	$0.034	**$0.259**
2030	$0.207	$0.021	$0.228	$0.003	**$0.231**	$0.035	**$0.266**
2031	$0.214	$0.021	$0.236	$0.003	**$0.238**	$0.036	**$0.274**
2032	$0.218	$0.021	$0.240	$0.002	**$0.242**	$0.036	**$0.278**
2033	$0.222	$0.021	$0.244	$0.003	**$0.246**	$0.037	**$0.283**
2034	$0.225	$0.021	$0.246	$0.003	**$0.249**	$0.037	**$0.286**
2035	$0.226	$0.021	$0.247	$0.003	**$0.250**	$0.037	**$0.287**
2036	$0.230	$0.021	$0.251	$0.003	**$0.254**	$0.038	**$0.292**
2037	$0.234	$0.021	$0.255	$0.003	**$0.258**	$0.039	**$0.297**
2038	$0.238	$0.021	$0.259	$0.003	**$0.262**	$0.039	**$0.301**
2039	$0.242	$0.021	$0.263	$0.003	**$0.266**	$0.040	**$0.306**
2040	$0.246	$0.021	$0.268	$0.003	**$0.271**	$0.041	**$0.311**
2041	$0.250	$0.021	$0.272	$0.003	**$0.275**	$0.041	**$0.316**
2042	$0.255	$0.021	$0.276	$0.003	**$0.279**	$0.042	**$0.321**
2043	$0.259	$0.021	$0.281	$0.003	**$0.284**	$0.043	**$0.326**
2044	$0.264	$0.021	$0.285	$0.003	**$0.288**	$0.043	**$0.332**
2045	$0.269	$0.021	$0.290	$0.003	**$0.293**	$0.044	**$0.337**
Net Present Value (4% Real Discount Rate)							
2016-2020	$0.691	$0.088	$0.780	$0.019	**$0.798**	$0.120	**$0.918**
2016-2030	$1.943	$0.231	$2.173	$0.040	**$2.213**	$0.332	**$2.545**
2016-2045	$3.404	$0.363	$3.767	$0.058	**$3.824**	$0.574	**$4.398**

4 Residential Sector

4.1 Measure Potential Savings

This chapter describes the residential measure potential savings using the methodology outlined in section 2.1 of the methodology chapter.

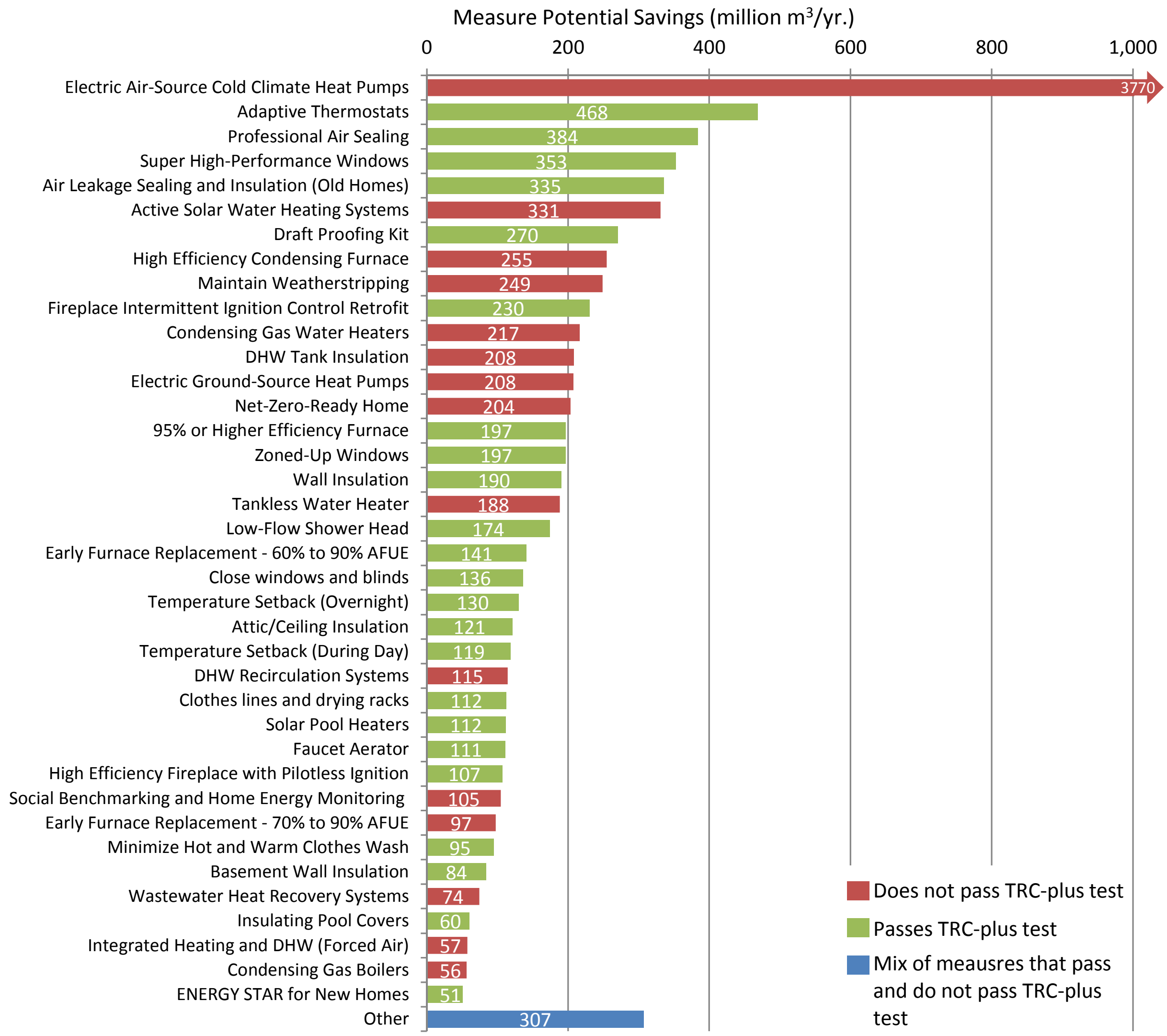
Exhibit 12 presents the maximum potential savings associated with each measure on an individual basis at the maximum possible rate of adoption, with colour-coding to differentiate those measures whose average TRC-plus ratio is greater than 1.0 versus less than 1.0. As was previously noted, a TRC-plus ratio that is greater than 1.0 indicates that a measure is economic, from the society resource use perspective.

In all cases, the measure savings are calculated relative to a reference case that includes natural changes in the building stock, but these savings do not account for the potential interactive effects with any other measure in the chart, or that some measures will compete with others, depending on customer preferences. For example, if insulation is installed in two houses with identical building envelopes, the house with the more efficient furnace will save less gas as a result of the insulation, whereas a house with a less efficient furnace will save more. These interactive effects will be taken into account in the analysis of technical, economic, and achievable potentials in later chapters, but maximum savings are shown here for the reader's reference. The savings potential of each measure are adjusted appropriately in determining the Ontario-wide technical potential savings.

Exhibit 13 presents results of a financial assessment of each measure. The TRC-plus column presents the benefit/cost ratio for each measure based on the TRC-plus test described previously. The TRC-plus test is performed separately for each type of dwelling and region, often with varying assumptions for costs and savings. Where this results in a range of TRC-plus ratios, the range is presented in the table. Where a single number is presented, that means the TRC-plus ratios did not vary significantly. For measures with a TRC-plus over 1.0 in some houses, the model applies the measure in those house types, but not in the dwellings where the ratio is below 1.0. In the case of low-income dwelling types, the threshold ratio of 0.7 is used. This test is also repeated in each year so that even if a measure fails the TRC-plus test in 2015, it may be included in a future year if it passes the TRC-plus test in that year.

The Payback column presents financial results from a customer perspective. The upfront capital cost of the measure is divided by annual customer cost savings in natural gas, electricity, and water consumption, to obtain the number of years for the measure to pay back its upfront cost. The calculation is repeated for each type of house type in each region, often with varying assumptions for costs and savings. Where this results in a range of payback periods, the range is presented. Where only one number appears, that indicates the payback did not vary significantly.

Exhibit 12 Residential Measure Potential Savings in 2030



1) *The measures that are red do not pass the TRC-plus test and the measures that are green pass the TRC-plus test with TRC-plus values greater than 1 for residential (excluding low-income) and greater than 0.7 for low-income. The "Other" category is a sum of the measures with potential savings of 50 million cubic metres or less. The category includes five measures that pass the TRC-plus test (adaptive thermostat for new construction, heat reflector panels, pipe wrap, programmable thermostats, and reduce temperature of domestic hot water (DHW).*

2) *Note: The "95% or Higher Efficiency Furnace" is for the installation of condensing furnaces with an annual fuel utilization efficiency (AFUE) of 95% or higher. The "High Efficiency Condensing Furnace" is for high efficiency condensing furnaces with regular PSC motor (AFUE of 96%).*

Exhibit 13 Measure Details - Residential

#	Residential Measure Name	TRC	Payback
1	95% or Higher Efficiency Furnace	0.7	17.2
2	Active Solar Water Heating Systems	0.1	Exceeds measure life
3	Adaptive Thermostats	2.0	3.7
4	Adaptive Thermostats - Direct Install	2.0 to 2.4	3.4 to 3.9
5	Adaptive Thermostats - Retail Purchase	2.0	4.2
6	Air Leakage Sealing and Insulation (Old Homes)	0.7 to 1.8	9.1 to life
7	Attic/Ceiling Insulation	1.0	14.0
8	Basement Wall Insulation (R-12)	0.8	18.8
9	Close windows and blinds	100.0	0.0
10	Clothes lines and drying racks	3.7 to 10.4	1.1 to 4.6
11	Condensing Gas Boilers	0.1 to 0.3	Exceeds measure life
12	Condensing Gas Water Heaters	0.1	Exceeds measure life
13	Crawlspace Insulation	0.1 to 0.2	Exceeds measure life
14	DHW Recirculation Systems (e.g. Metlund D'MAND®)	0.1 to 0.4	12.4 to life
15	DHW Tank Insulation	0.2 to 0.6	12.3 to life
16	Draft Proofing Kit	2.3	0.3
17	Early Furnace Replacement - 60% AFUE - 90% AFUE Furnace	0.9	2.5
18	Early Furnace Replacement - 70% AFUE - 90% AFUE Furnace	0.5	Exceeds measure life
19	Early Hot Water Heater Replacement (0.575 to 0.62 EF)	0.2	Exceeds measure life
20	Electric Air-Source Cold Climate Heat Pumps	0.3 to 0.7	Exceeds measure life
21	Electric Ground-Source Heat Pumps	0.1 to 0.4	Exceeds measure life
22	ENERGY STAR for New Homes	1.3	11.9
23	ENERGY STAR for New Homes	1.3	11.9
24	Faucet Aerator	11.3 to 31.6	0.1
25	Fireplace Intermittent Ignition Control Retrofit	1.2	6.2
26	Heat Reflector Panels	4.1	3.9
27	High Efficiency Condensing Furnace	0.2	Exceeds measure life
28	High Efficiency Fireplace with Pilotless Ignition	2.9 to 3.3	4.7 to 5.4
29	High Efficiency Gas Storage Water Heater	0.2	Exceeds measure life
30	High-Efficiency (ENERGY STAR®) Clothes Washers	0.3 to 0.8	2.3 to 3.0
31	High-Efficiency (ENERGY STAR®) Clothes Washers	0.3 to 0.8	2.3 to 3.0
32	High-Efficiency (ENERGY STAR®) Dishwashers	0.1	10.7 to life
33	High-Efficiency Gas Clothes Dryers	0.2 to 0.4	Exceeds measure life
34	High-Efficiency Gas-Fired Pool Heaters	0.1	Exceeds measure life
35	High-Efficiency Heat Recovery Ventilators (HRVs)	0.1 to 0.3	Exceeds measure life
36	Insulating Pool Covers	1.0 to 1.3	3.3 to 4.1
37	Integrated Heating and DHW (Forced Air Heating)	0.1	Exceeds measure life
38	Integrated Heating and DHW (Hydronic Heating)	0.1 to 0.2	Exceeds measure life
39	Low-Flow Shower Head	3.3 to 3.5	0.5
40	Maintain Weatherstripping	0.2 to 0.7	4.9 to life
41	Minimize Hot and Warm Clothes Wash	100.0	0.0
42	Net-Zero-Ready Home	0.0	Exceeds measure life
43	Net-Zero-Ready Home	0.0	Exceeds measure life
44	Pipe Wrap	48.7	0.2
45	Professional Air Sealing/Weather Stripping/Caulking	0.4 to 2.0	8.0 to life
46	Programmable Thermostat	1.9	5.6
47	Reduce Temperature of DHW	100.0	0.0
48	Slab Insulation (Unfinished Basements)	0.1	Exceeds measure life
49	Social Benchmarking and Home Energy Monitoring	0.0 to 0.5	3.1 to life
50	Social Benchmarking and Home Energy Monitoring	0.0 to 0.5	3.1 to life
51	Solar Pool Heaters	2.5	5.0
52	Solar Pre-Heated Make-Up Air Systems (e.g., SolarWall®)	0.1 to 0.2	Exceeds measure life
53	Super High-Performance Windows	0.4 to 2.4	6.6 to life
54	Tankless Water Heater	0.2	Exceeds measure life
55	Temperature Setback (During Day)	100.0	0.0
56	Temperature Setback (Overnight)	100.0	0.0
57	Use sensor for clothes dryer	0.3 to 0.8	12.0 to life
58	Wall Insulation	0.2 to 1.3	12.1 to life
59	Wastewater Heat Recovery Systems	0.1 to 0.3	Exceeds measure life
60	Zoned-Up Windows: (ENERGY STAR) Rating for a Colder Climate	0.3 to 2.0	7.9 to life

4.2 Base Year Natural Gas Energy Use

4.2.1 Residential Sector Segmentation

The residential sector includes the following sub-sectors:

- Single detached, gas-heated, pre-1980
- Single detached, gas-heated, 1980-1996
- Single detached, gas-heated, 1997-present
- Low-income detached, gas-heated, all ages
- Attached, gas-heated, pre-1980
- Attached, gas-heated, 1980-1996
- Attached, gas-heated, 1997-present
- Low-income attached, gas-heated, all ages
- Other/Mobile, gas-heated

4.2.2 End Uses

The residential sector includes the following end uses:

- Space heating: Forced air furnaces and hydronic systems
- Domestic water heating: Tankless and storage type gas-fired water heaters
- Cooking: Gas-fired ranges, ovens, and cooktops
- Fireplaces: Gas-fired fireplaces
- Clothes dryers: Gas-fired clothes dryers
- Swimming pool heaters: Gas-fired swimming pool heathers
- Other: Barbecues, patio heater, patio lights, etc.

4.2.3 End use Saturation and Fuel Share Data

Saturation is the presence of the end use in each sub-sector. All homes are assumed to have space heating, domestic hot water, cooking, and “other” end uses. Data from residential end use surveys and market surveys were used to determine some of the saturations for space cooling, dryers, washers, dishwashers, pool heaters, and fireplaces for the base year. The saturation also accounts for cases where multiple pieces of equipment exist in a home (e.g. homes with more than one fireplace). Where not enough reliable data was available from surveys or no data was provided by the utilities for certain end uses, saturations were based on ICF’s experience.

Accounts are based on the total customer gas consumption provided by the utilities and then are divided into segments. For the residential sector, segments have been assigned based on residential end use surveys and market surveys.

Fuel share is the end use energy provided by natural gas divided by the total end use energy provided by all fuel types. The fuel share for each sub-sector and end use is based on residential end use surveys and market surveys provided by the utilities. Where not enough reliable data were available from surveys or no data was provided by the utilities for certain end uses, values were based on ICF’s experience. Gas heated homes were assumed to have 5% of supplementary electric heat, which was based on ICF’s past experience with natural gas conservation potential studies.

Energy use intensities (EUIs) for dryers and ranges were derived from information in “Energy Consumption of Major Appliances Shipped in Canada, Trends for 1990 -2010” published by Natural Resources[56] Canada (electric EUI converted to gas with an assumed standard efficiency for each

[56] Natural Resources Canada’s Office of Energy Efficiency, “Energy Consumption of Major Appliances Shipped in Canada, Trends for 1990 -2010,” Accessed January 2016, http://oee.nrcan.gc.ca/publications/statistics/cama12/cama12.pdf.

appliance type[57]). EUIs for domestic hot water were estimated based on ICF's experience. EUIs for space heating, fireplaces, pool heaters, and other gas uses were calibrated to yield a base year total gas consumption that matched the values provided by the utilities.

Low-income dwellings were generally assumed to have the same end uses, with similar characteristics, as the other dwellings. However, low-income residential dwellings were assumed to have fewer pool heaters and gas fireplaces than the rest of the residential sub-sector, based on data from Union Gas. [58]

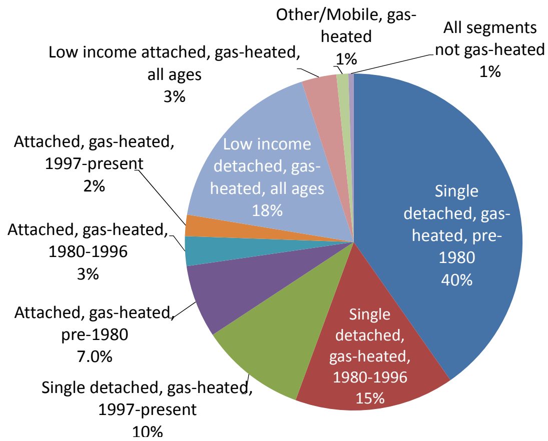
4.2.4 Base Case Estimates

Exhibit 14 through Exhibit 16 present the estimated base year consumption of natural gas, broken out by dwelling type and region, and then by end use. The following observations can be made:

Single detached homes (not including low-income) accounted for approximately 65% of consumption, while the low-income segments accounted for approximately 20%.

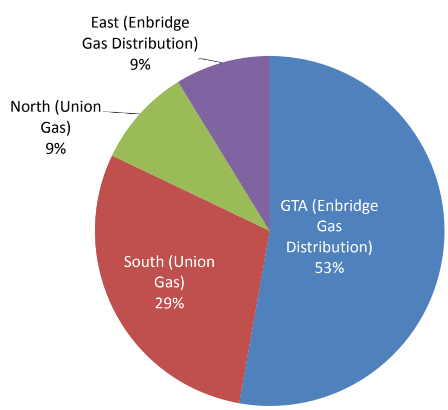
In total, dwellings where gas is not the primary space heating fuel accounted for less than 1% of the residential consumption.

Exhibit 14 Residential Natural Gas Consumption by Dwelling Type - Base Year (2014)



Dwellings in the GTA portion of Enbridge Gas Distribution's service territory accounted for approximately 53% of the residential gas consumed in Ontario in the base year, with the southern region of Union Gas' service territory accounting for approximately 29%. The eastern region of Enbridge Gas Distribution's territory and the northern region of Union Gas' territory accounted for approximately 9% each.

Exhibit 15 Residential Natural Gas Consumption by Region - Base Year (2014)



[57] The average efficiency for gas dryers was assumed to be 85%. The average efficiency for ranges was assumed to be 55%. These values are drawn from ICF's internal end use database.

[58] Saturation of pools in low-income was reduced by 94% relative to the saturation in other dwellings. Saturation of fireplaces was also reduced by 12% in most cases.The reduction was accomplished by redistributing pools and fireplaces from the low-income segments to the corresponding other houses within a given sub-sector, while limiting the new saturation in these other houses not to exceed 100%.

Space heating accounted for approximately 72% of residential consumption, with DWH consuming 13%. Fireplaces, which were broken out separately from space heating, accounted for 5%.

Exhibit 16 Residential Natural Gas Consumption by End Use - Base Year (2014)

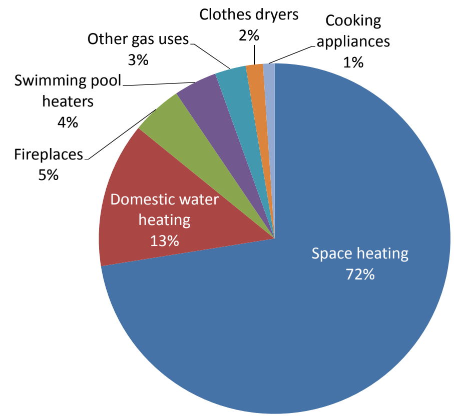


Exhibit 17 Residential Base Year (2014) Natural Gas Consumption by Dwelling Type and Region

Dwelling Type	Base Case Consumption, 2014 (1000 m^3/yr.)						
	Enbridge Gas Distribution			Union Gas			Grand Total
	GTA	East	Total	South	North	Total	
Single detached, gas-heated, pre-1980	1,497,726	247,447	1,745,172	1,016,882	371,466	1,388,349	3,133,521
Single detached, gas-heated, 1980-1996	542,196	93,629	635,825	432,629	121,736	554,366	1,190,191
Single detached, gas-heated, 1997-present	537,509	89,333	626,842	129,746	31,328	161,074	787,917
Single detached, not gas-heated, pre-1980	3,692	607	4,300	7,357	3,165	10,522	14,822
Single detached, not gas-heated, 1980-1996	2,018	318	2,336	5,537	2,010	7,547	9,883
Single detached, not gas-heated, 1997-present	1,887	309	2,196	1,947	371	2,318	4,513
Low income detached, gas-heated, all ages	680,021	113,928	793,949	420,306	140,887	561,193	1,355,142
Low income detached, not gas-heated, all ages	1,662	281	1,943	3,236	1,159	4,394	6,337
Single Detached Total	3,266,710	545,853	3,812,564	2,017,642	672,122	2,689,764	6,502,328
Attached, gas-heated, pre-1980	371,187	59,856	431,043	98,711	14,076	112,788	543,830
Attached, gas-heated, 1980-1996	115,090	18,640	133,730	78,235	9,353	87,587	221,318
Attached, gas-heated, 1997-present	115,272	17,876	133,148	23,605	2,539	26,144	159,291
Attached, not gas-heated, pre-1980	659	106	765	-	-	-	765
Attached, not gas-heated, 1980-1996	335	55	389	1,021	-	1,021	1,410
Attached, not gas-heated, 1997-present	339	57	396	570	-	570	966
Low income attached, gas-heated, all ages	170,610	27,393	198,003	54,591	7,104	61,695	259,698
Low income attached, not gas-heated, all ages	340	60	401	362	-	362	763
Attached Total	773,831	124,043	897,874	257,095	33,072	290,167	1,188,041
Other/Mobile, gas-heated	65,555	12,396	77,951	4,397	5,190	9,588	87,539
Other/Mobile, not gas-heated	127	21	148	-	-	-	148
Other/Mobile Total	65,682	12,417	78,099	4,397	5,190	9,588	87,687
Non-Low-Income Total	3,253,591	540,650	3,794,241	1,800,638	561,235	2,361,874	6,156,115
Low-Income Total	852,633	141,663	994,296	478,496	149,150	627,645	1,621,941
Grand Total	**4,106,224**	**682,313**	**4,788,537**	**2,279,134**	**710,385**	**2,989,519**	**7,778,056**

Exhibit 17 shows the detailed breakdown of energy consumption of all the dwelling types that use natural gas. Since dwellings that use natural gas, but do not use natural gas for heating (not gas-heated dwellings) account for a very small fraction of the overall energy consumption, subsequent exhibits have all of these dwellings combined into one category called “not gas-heated”.

4.3 Reference Case

4.3.1 Natural replacement

The EUI projections were based on the natural replacement of equipment and expected performance of new equipment. The residential sector used assumed rates of change that varied with the measure being considered, drawing on data from the residential end use surveys[59] to assess where a given measure would be on the curve of natural adoption in the marketplace. If, for example, the measure is still extremely rare and has a very long customer payback, in ICF's experience it would be appropriate to assume a negligible change in natural penetration over the study period. This assumption is based on the typical S-shaped adoption curve for new products. The initial "tail" of the S-shape may be long – if there was no evidence that adoption of the measure had begun to accelerate, we did not assume that it would do so during the study period.

If the measure is being adopted widely now, such as a product that has an established market share versus the standard technology in new purchases, it is more appropriate to assume that the measure is now on the steeper, relatively straight part of the S-shaped adoption curve. ICF then assumed the measure would continue to have a similar market share going forward, which means the increase in penetration would be based on a combination of the natural rate of stock turnover and the market share of the efficient technology.

Other assumptions included that the number of renovation projects were assumed to be about twice the number of new construction projects – renovations were assumed to improve space heat EUI by 2%,[60] and that new homes built prior to 2017 were assumed to have an EnerGuide Rating of 76 and homes built in 2017 or later were assumed to have an EnerGuide Rating of 80.[61]

4.3.2 Codes and Standards

Changes to codes and standards have been modelled through their effect on energy demand (e.g. improved insulation) and equipment efficiency. New standards for washers, dryers, and dishwashers were accounted for by changing the performance of the new stock in the years when the standards take effect.

4.3.3 Reference Case Forecast of Natural Gas Use

Exhibit 18 through Exhibit 22 show the estimated reference forecast of natural gas consumption, broken out by dwelling type and region, and then by end use.

As shown in Exhibit 18 and Exhibit 19, the residential consumption of natural gas in Ontario is expected to rise from approximately 7,778 million cubic metres in 2014 to approximately 8,882 million cubic metres in 2030, in the absence of new conservation programs, which represents an increase of approximately 14%.

The share of residential consumption by single detached homes (excluding low-income) and low-income detached homes is expected to remain the same at 65% and 21% of consumption over the period 2014 to 2030, respectively, with improvements in efficiency in space heating and water heating largely offset by conversions of existing homes and the growth in other end uses. Most of

[59] Enbridge Gas Distribution, "Residential Market Survey 2013," 2013. Union Gas, "2014 Market Penetration of Natural Gas Appliances & Energy Conservation Intentions in The Single Family Market," May 2015.

[60] These assumptions were based on ICF experience from carrying out multiple natural gas and electricity conservation potential studies

[61] The EnerGuide rating is a standard measure of home energy performance. A rating of 100 indicates a house with no net purchased energy on an annual basis. A rating of 80 or higher for a new house is considered excellent by Natural Resources Canada. http://www.nrcan.gc.ca/energy/efficiency/housing/new-homes/5035

the overall growth is expected to come from new construction, with more growth expected from new attached homes than from detached homes.

The consumption of attached dwellings is expected to remain at about 13% from 2014 to 2030. In total, dwellings where gas is not the primary space heating fuel will continue to account for less than 1% of residential natural gas consumption.

Exhibit 18 Residential Natural Gas Consumption by Building Type

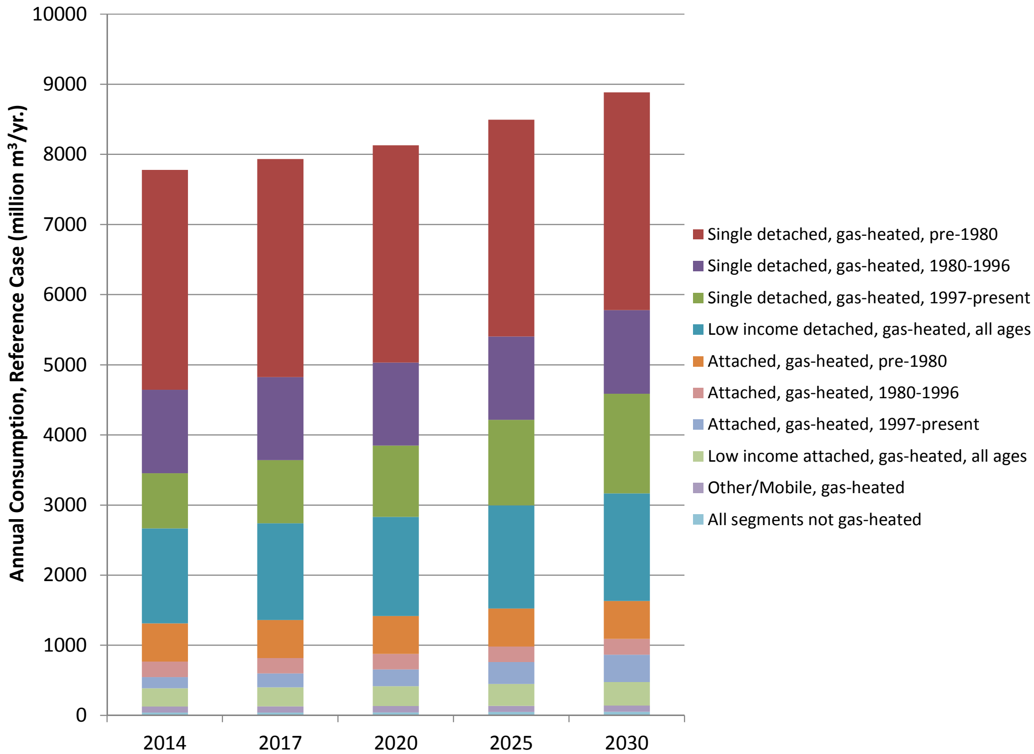


Exhibit 19 Residential Natural Gas Consumption by Sub-sector in Years 2014, 2017, 2020, 2025, and 2030

Sub-Sector	Consumption (million m^3/yr.)				
	2014	2017	2020	2025	2030
Single detached, gas-heated, pre-1980	3,134	3,111	3,099	3,092	3,103
Single detached, gas-heated, 1980-1996	1,190	1,184	1,184	1,187	1,192
Single detached, gas-heated, 1997-present	788	899	1,018	1,223	1,421
Low income detached, gas-heated, all ages	1,355	1,380	1,412	1,471	1,534
Single Detached Total	6,467	6,574	6,713	6,973	7,251
Attached, gas-heated, pre-1980	544	542	540	541	542
Attached, gas-heated, 1980-1996	221	221	221	222	223
Attached, gas-heated, 1997-present	159	197	239	314	391
Low income attached, gas-heated, all ages	260	272	285	310	336
Attached Total	1,184	1,231	1,286	1,388	1,492
Other/Mobile, gas-heated	88	88	88	89	89
All segments not gas-heated	40	41	44	47	51
Non-Low-Income, Gas Heated Total	6,124	6,242	6,389	6,667	6,962
Low-Income, Gas Heated Total	1,615	1,652	1,697	1,781	1,870
Total	**7,778**	**7,934**	**8,130**	**8,496**	**8,882**

As shown in Exhibit 20 and Exhibit 21, the proportion of residential consumption in each of the four regions is expected to remain relatively constant, with 2030 percentages all within 1% of the base year consumption.

Exhibit 20 Residential Natural Gas Consumption by Regions

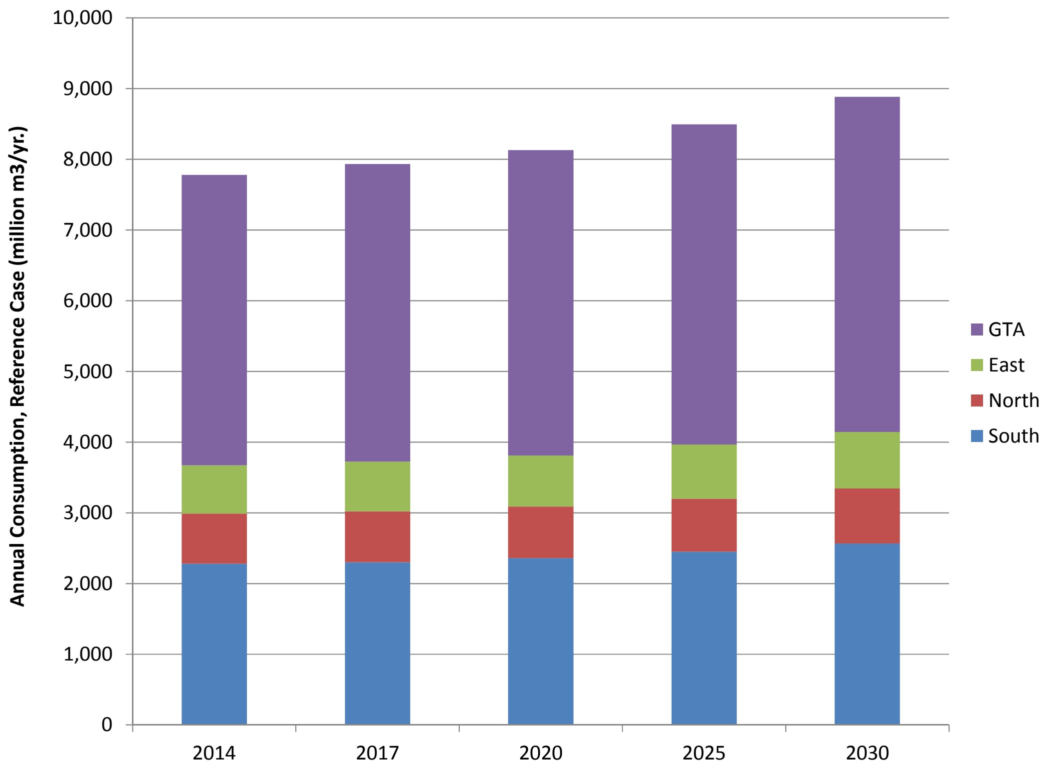


Exhibit 21 Residential Natural Gas Consumption by Region

Utility	Region	Consumption (million m^3/yr.)				
		2014	2017	2020	2025	2030
Enbridge Gas Distribution	GTA	4,106	4,209	4,319	4,531	4,739
	East	682	704	724	765	800
Union Gas	North	710	718	729	749	777
	South	2,279	2,303	2,359	2,451	2,567
Total		7,778	7,934	8,130	8,496	8,882

As shown in Exhibit 22 and Exhibit 23, space heating is expected to account for only 69% of residential consumption in 2030, down from 72% in the base year. Natural gas use for domestic hot water is expected to remain relatively consistent at 12-13% and fireplaces are expected to continue to account for approximately 5% or residential natural gas consumption. The other end uses (barbecues, patio heater, patio lights, etc.) are expected to grow from approximately 3% to over 7% of residential consumption from 2014 to 2030.

Exhibit 22 Residential Natural Gas Consumption by End Use

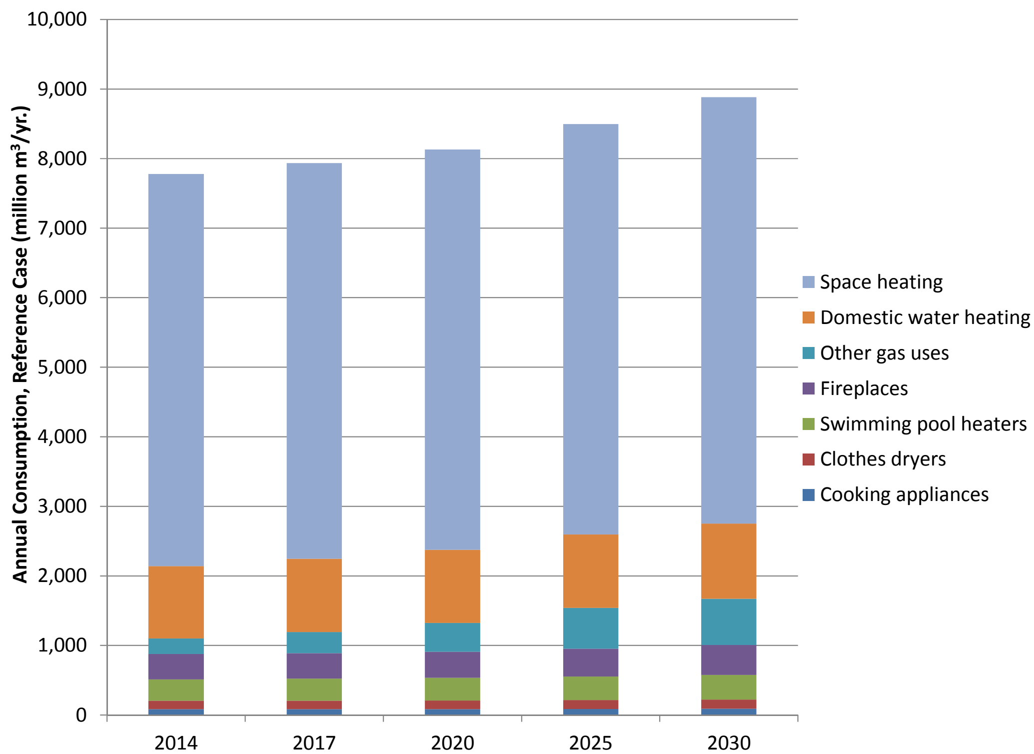


Exhibit 23 Residential Natural Gas Consumption by End Use

End Use	Consumption (million m^3/yr.)				
	2014	2017	2020	2025	2030
Space heating	5,638	5,689	5,756	5,899	6,132
Domestic water heating	1,041	1,051	1,049	1,059	1,080
Other gas uses	222	306	416	585	665
Fireplaces	364	366	375	400	431
Swimming pool heaters	308	317	326	340	352
Clothes dryers	123	123	124	128	133
Cooking appliances	82	83	84	87	90
Total	7,778	7,934	8,130	8,496	8,882

4.4 Technical Potential

This section presents estimates of residential technical potential based on the methodology discussed in section 2.6. Exhibit 24 through Exhibit 31 show the technical potential savings for the residential sector.

As shown in Exhibit 24 and Exhibit 25, the technical potential is estimated to reduce residential consumption by 49% by 2020, or from 8,882 million cubic metres to 4,124 million cubic metres in 2020, and by 72% to 2,511 million cubic metres by 2030.[62]

Exhibit 24 Residential Technical Potential and Reference Case Consumptions

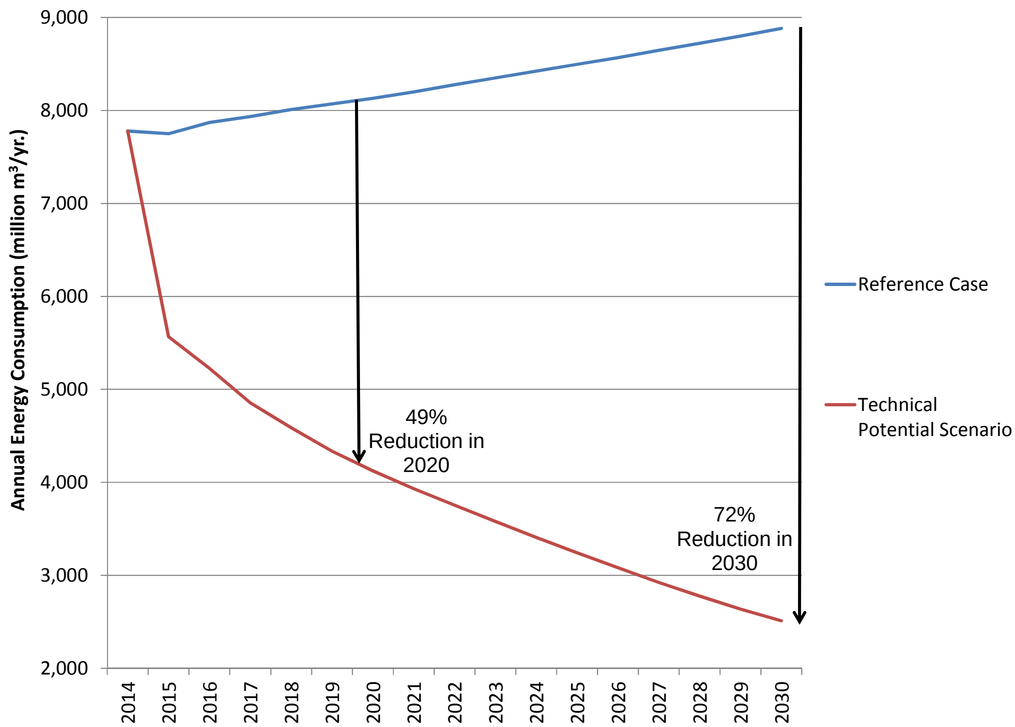


Exhibit 25 Residential Technical Potential and Reference Case Consumptions

Milestone Years	Consumption (million m^3/yr.)	
	Reference Case	Technical Potential Scenario
2014	7778	7778
2015	7751	5566
2016	7871	5228
2017	7934	4855
2018	8009	4588
2019	8070	4336
2020	8130	4124
2025	8496	3243
2030	8882	2511

[62] This high savings potential is largely due to the inclusion of heat pump measures in the technical potential. These measures have a large impact on the space heating energy consumption of homes. However, as noted in Section 4.1, these measures do not pass the TRC-plus test. As such, they are not included in the savings potential for subsequent scenarios.

As shown in Exhibit 26 and Exhibit 27, the technical savings potential for detached homes (excluding low-income) increased by about 38% from 2,508 million cubic metres in 2020 to 4,023 million cubic metres in 2030 while the share of the total technical potential savings attributed to detached homes (excluding low-income) remained at 63% from 2020 to 2030. The technical potential savings for attached homes (excluding low-income) increased by 41% from 465 million cubic metres in 2020 to 793 million cubic metres in 2030 while the share of total technical potential savings attributed to attached homes (excluding low-income) remained at 12% from 2020 to 2030. The technical potential savings for mobile homes increased from 28 million cubic metres in 2020 to 38 million cubic metres in 2030 while the portion of total technical potential savings attributed to mobile homes generally remains at 1% in all years. Although the technical savings potential for low-income homes increases from 1,004 million cubic metres in 2020 to 1,517 million cubic metres in 2030, the share of total technical potential savings attributed to low-income homes decreases from 25% to 24% from 2020 to 2030.

Space heating accounted for nearly 76% and DWH accounted for approximately 13% of total residential technical potential savings by 2020. Fireplaces, which were broken out separately from space heating, accounted for approximately 6% and clothes dryers and swimming pool heaters each accounted for 3% of total residential technical potential savings by 2020. By 2030, the distribution of savings between the end uses remained largely unchanged with space heating accounting for about 79% of residential technical savings potential, DWH accounting for 12%, fireplaces accounting for 4%, swimming pool heaters accounting for 3%, and clothes dryers accounting for 2%.

Exhibit 26 Graph of Residential Technical Potential Savings by End Use, Year, and Sub-Sector

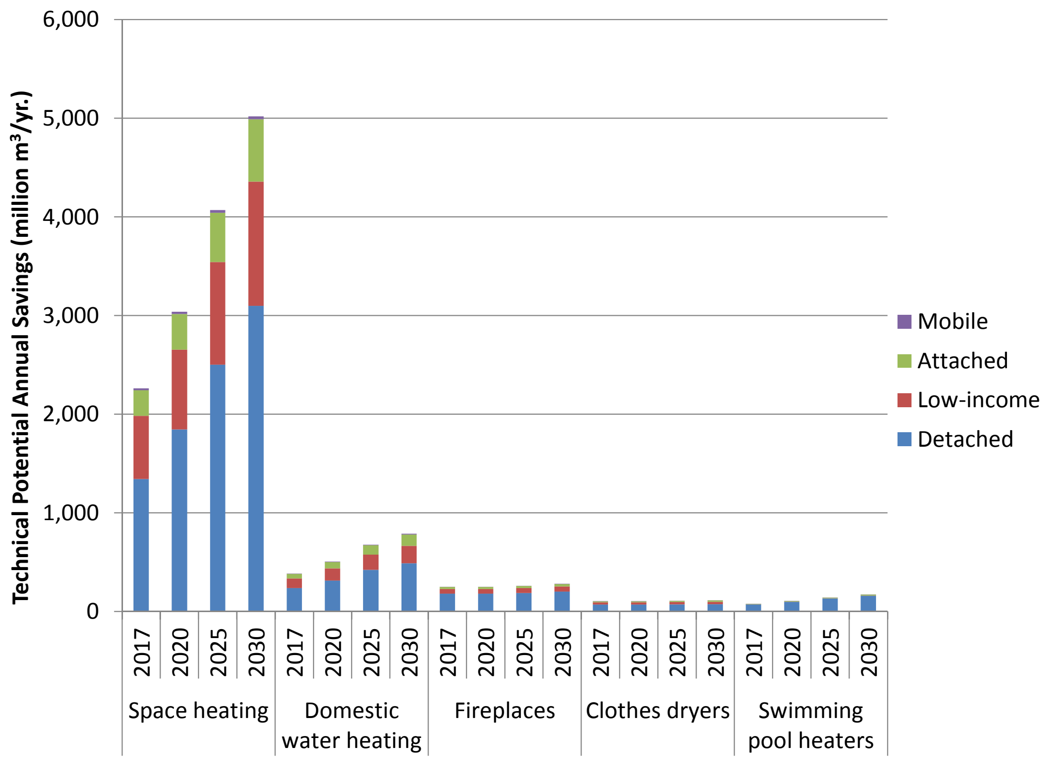


Exhibit 27 Table of Residential Technical Potential Savings by End Use, Year, and Sub-Sector[63]

End Use	Milestone Years	Savings (million m³/yr.)				
		Detached	Low-income	Attached	Mobile	Total
Space heating	2017	1,343	640	260	18	2,262
	2020	1,844	810	362	22	3,038
	2025	2,502	1,039	500	26	4,067
	2030	3,097	1,260	632	29	5,018
Domestic water heating	2017	237	97	48	3	386
	2020	315	121	67	4	507
	2025	422	155	94	6	676
	2030	489	177	115	6	788
Fireplaces	2017	180	48	20	1	249
	2020	180	48	20	1	249
	2025	188	50	21	1	260
	2030	202	53	24	1	280
Clothes dryers	2017	70	23	11	0	104
	2020	70	23	11	0	105
	2025	72	24	12	0	109
	2030	74	25	13	0	113
Swimming pool heaters	2017	72	1	4	0	77
	2020	99	1	6	0	106
	2025	131	2	7	0	141
	2030	161	2	9	0	172
Grand Total	2017	1,903	810	343	23	3,079
	2020	2,508	1,004	465	28	4,006
	2025	3,315	1,270	635	33	5,253
	2030	4,023	1,517	793	38	6,371

As shown in Exhibit 28 and Exhibit 29, the technical potential savings in the Enbridge Gas Distribution's service territory increased by 37% from 2,498 million cubic metres in 2020 to 3,977 million cubic metres in 2030. The technical potential savings in the Union Gas' service territory also increased by 37% from 1,508 million cubic metres in 2020 to 2,394 million cubic metres in 2030. From 2020 to 2030, Enbridge Gas Distribution's service territory accounted for approximately 62% of the residential technical savings potential, with dwellings in Union Gas' service territory accounting for the remaining 38%.

As shown in Exhibit 30 and Exhibit 31, the technical potential savings of existing homes increased from 3,901 million cubic metres in 2020 to 5,829 million cubic metres in 2030 while the technical potential savings of new homes increased from 104 million cubic metres in 2020 to 542 million cubic metres in 2030. Existing homes accounted for approximately 97% of the residential technical savings potential in 2020 which decreased to 5,829 million cubic metres or 91% of the residential technical savings potential in 2030.

[63] Savings in this table and are all subsequent tables in this chapter are rounded to the nearest million cubic metre. The value of "0" does not necessarily mean there are no savings

Exhibit 28 Graph of Residential Technical Potential Savings by End Use, Year, and Utility

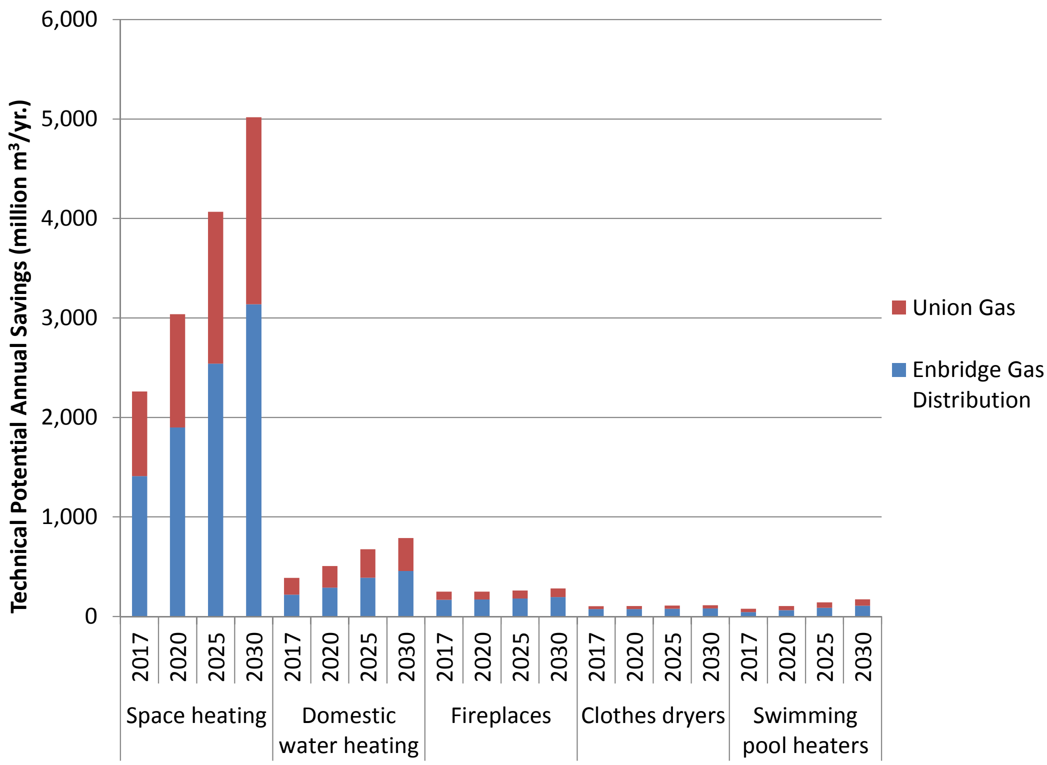


Exhibit 29 Table of Residential Technical Potential Savings by End Use, Year, and Utility

End Use	Milestone Years	Savings (million m^3/yr.)		
		Enbridge Gas Distribution	Union Gas	Total
Space heating	2017	1,412	850	2,262
	2020	1,900	1,137	3,038
	2025	2,542	1,525	4,067
	2030	3,139	1,879	5,018
Domestic water heating	2017	220	166	386
	2020	290	217	507
	2025	389	287	676
	2030	455	332	788
Fireplaces	2017	166	83	249
	2020	170	79	249
	2025	179	80	260
	2030	194	86	280
Clothes dryers	2017	73	31	104
	2020	74	31	105
	2025	77	32	109
	2030	81	32	113
Swimming pool heaters	2017	45	33	77
	2020	63	43	106
	2025	86	54	141
	2030	108	64	172
Grand Total	2017	1,916	1,163	3,079
	2020	2,498	1,508	4,006
	2025	3,274	1,979	5,253
	2030	3,977	2,394	6,371

Exhibit 30 Graph of Residential Technical Potential Savings by End Use, Year, and Vintage

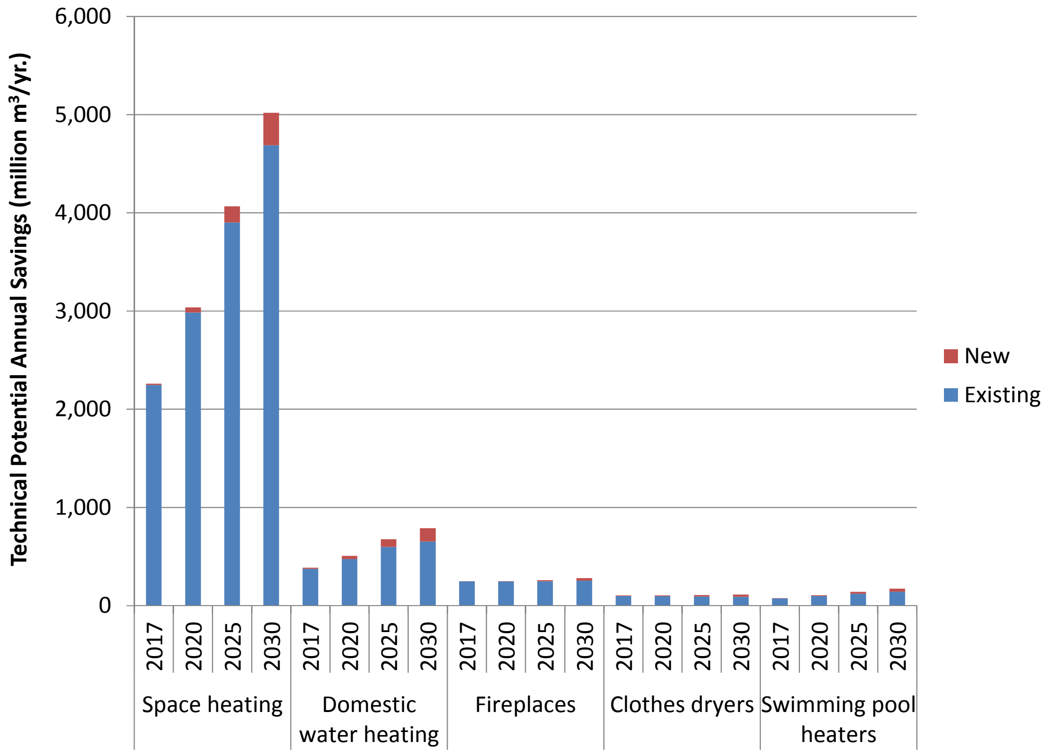


Exhibit 31 Table Residential Technical Potential Savings by End Use, Year, and Vintage

End Use	Milestone Years	Savings (million m^3/yr.)		
		Existing	New	Total
Space heating	2017	2,248	14	2,262
	2020	2,985	53	3,038
	2025	3,902	165	4,067
	2030	4,688	330	5,018
Domestic water heating	2017	375	11	386
	2020	475	31	507
	2025	597	80	676
	2030	654	134	788
Fireplaces	2017	249	1	249
	2020	246	3	249
	2025	248	12	260
	2030	255	25	280
Clothes dryers	2017	100	4	104
	2020	97	8	105
	2025	93	16	109
	2030	90	23	113
Swimming pool heaters	2017	74	3	77
	2020	98	8	106
	2025	123	18	141
	2030	142	31	172
Grand Total	2017	3,047	32	3,079
	2020	3,901	104	4,006
	2025	4,963	290	5,253
	2030	5,829	542	6,371

4.5 Economic Potential

This section presents estimates of residential economic potential based on the methodology discussed in section 2.7. Exhibit 32 through Exhibit 39 present the economic potential savings for the residential sector.

As shown in Exhibit 32 and Exhibit 33, the economic potential is estimated to reduce residential natural gas consumption by 25% from 8,130 million cubic metres to 6,109 million cubic metres in 2020 and by 27% from 8,882 million cubic metres to 6,503 million cubic metres by 2030.

Exhibit 32 Residential Reference Case, Technical Potential, and Economic Potential Consumptions

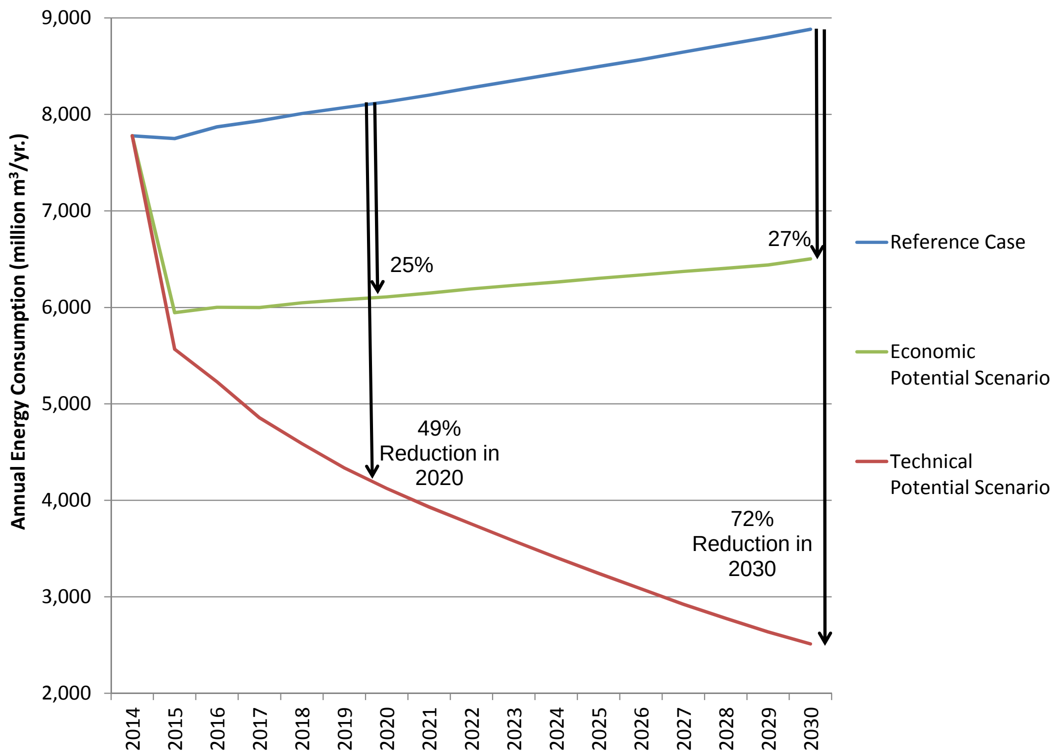


Exhibit 33 Residential Reference Case, Technical Potential, and Economic Potential Consumptions

Milestone Years	Consumption (million m^3/yr.)		
	Reference Case	Technical Potential Scenario	Economic Potential Scenario
2014	7778	7778	7778
2015	7751	5566	5946
2016	7871	5228	6001
2017	7934	4855	5999
2018	8009	4588	6047
2019	8070	4336	6079
2020	8130	4124	6109
2025	8496	3243	6301
2030	8882	2511	6503

As shown in Exhibit 34 and Exhibit 35, the economic savings potential for detached homes (excluding low-income) increased by 15% from 1,260 million cubic metres in 2020 to 1,486 million cubic metres in 2030 while the share of total economic potential savings attributed to detached homes (excluding low-income) remained at 62%. The economic savings potential for attached homes (excluding low-income) increased by 20% from 221 million cubic metres in 2020 to 277 million cubic metres in 2030 while the portion of total economic potential savings attributed to attached homes (excluding low-income) remained relatively stable increasing from 11% to 12%. The economic savings potential for mobile homes increased by 14% from 19 million cubic metres in 2020 to 22 million cubic metres in 2030 while the share of total economic potential savings attributed to mobile homes remained at 1%. The economic savings potential for low-income homes increased by 12% from 521 million cubic metres in 2020 to 595 million cubic metres in 2030 while the share of total economic potential savings attributed to low-income homes decreased from 26% to 25%, respectively.

As shown in Exhibit 34 and Exhibit 35, space heating accounts for approximately 66% of residential economic savings potential by 2020 and DWH accounts for approximately 12%. Fireplaces accounted for approximately 12%. Swimming pool heaters account for nearly 4% of the savings, with the remaining 5% attributed to clothes dryers. By 2030, the distribution of savings between the end uses remained largely unchanged with space heating accounting for about 66% of residential economic savings potential, DWH accounting for 11%, fireplaces accounting for 12%, swimming pool heaters accounting for 6%, and clothes dryers accounting for 5%.

Exhibit 34 Graph of Residential Economic Potential Savings by End Use, Year, and Sub-Sector

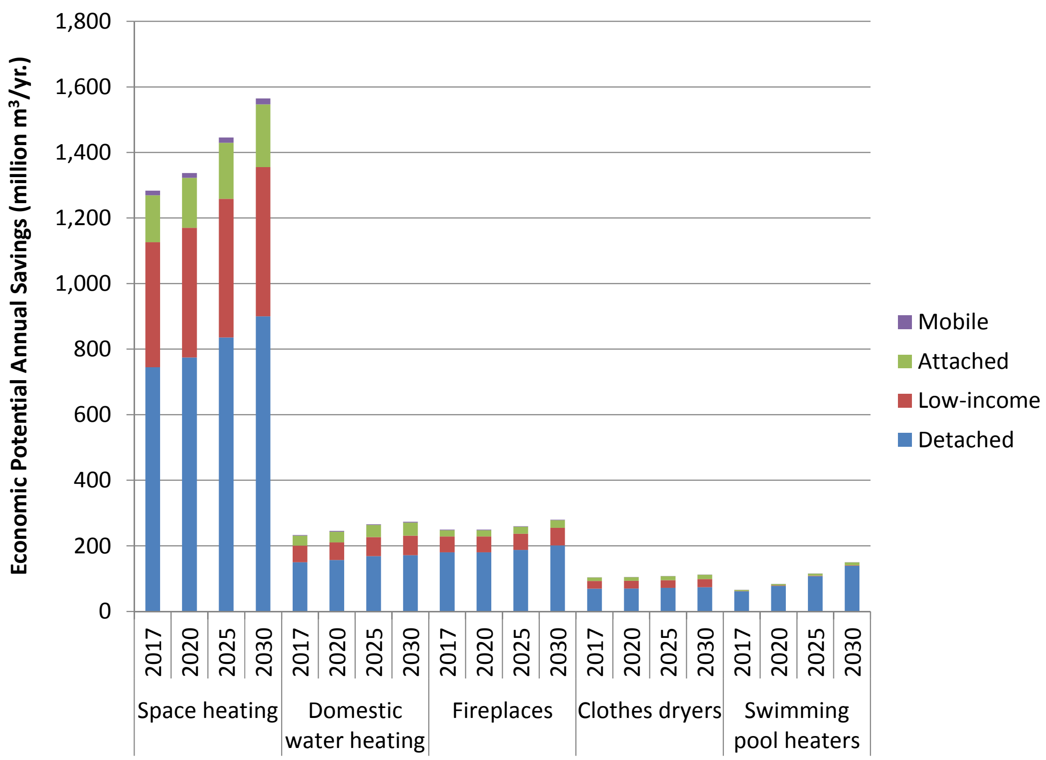


Exhibit 35 Table of Residential Economic Potential Savings by End Use, Year, and Sub-Sector

End Use	Milestone Years	Savings (million m^3/yr.)				
		Detached	Low-income	Attached	Mobile	Total
Space heating	2017	745	382	143	14	1,283
	2020	775	395	153	15	1,337
	2025	836	423	171	16	1,446
	2030	900	455	192	18	1,565
Domestic water heating	2017	150	51	30	2	233
	2020	157	54	33	2	245
	2025	168	58	37	2	266
	2030	171	60	40	2	273
Fireplaces	2017	180	48	20	1	249
	2020	180	48	20	1	249
	2025	188	50	21	1	260
	2030	202	53	24	1	280
Clothes dryers	2017	69	23	11	0	104
	2020	70	23	11	0	105
	2025	71	24	12	0	108
	2030	74	25	13	0	112
Swimming pool heaters	2017	61	1	4	0	66
	2020	78	1	5	0	84
	2025	108	2	6	0	116
	2030	139	2	8	0	149
Grand Total	2017	1,205	505	207	18	1,935
	2020	1,260	521	221	19	2,021
	2025	1,371	556	248	20	2,195
	2030	1,486	595	277	22	2,379

As shown in Exhibit 36 and Exhibit 37, the economic potential savings in the Enbridge Gas Distribution's service territory increased by 16% from 1,272 million cubic metres in 2020 to 1,507 million cubic metres in 2030 while the economic potential savings in the Union Gas' service territory increased by 14% from 748 million cubic metres in 2020 to 873 million cubic metres in 2030. From 2020 to 2030, Enbridge Gas Distribution's service territory accounted for approximately 63% of the residential economic savings potential, with dwellings in Union Gas' service territory accounting for the remaining 37%.

As shown in Exhibit 38 and Exhibit 39, the economic potential savings of existing homes increased by 9% from 1,977 million cubic metres in 2020 to 2,178 million cubic metres in 2030 while the economic potential savings of new homes increased by 78% from 44 million cubic metres in 2020 to 201 million cubic metres in 2030. Existing homes accounted for approximately 98% of the residential economic savings potential in 2020 which decreased to 92% of the residential technical savings potential in 2030.

Exhibit 36 Graph of Residential Economic Potential Savings by End Use, Year, and Utility

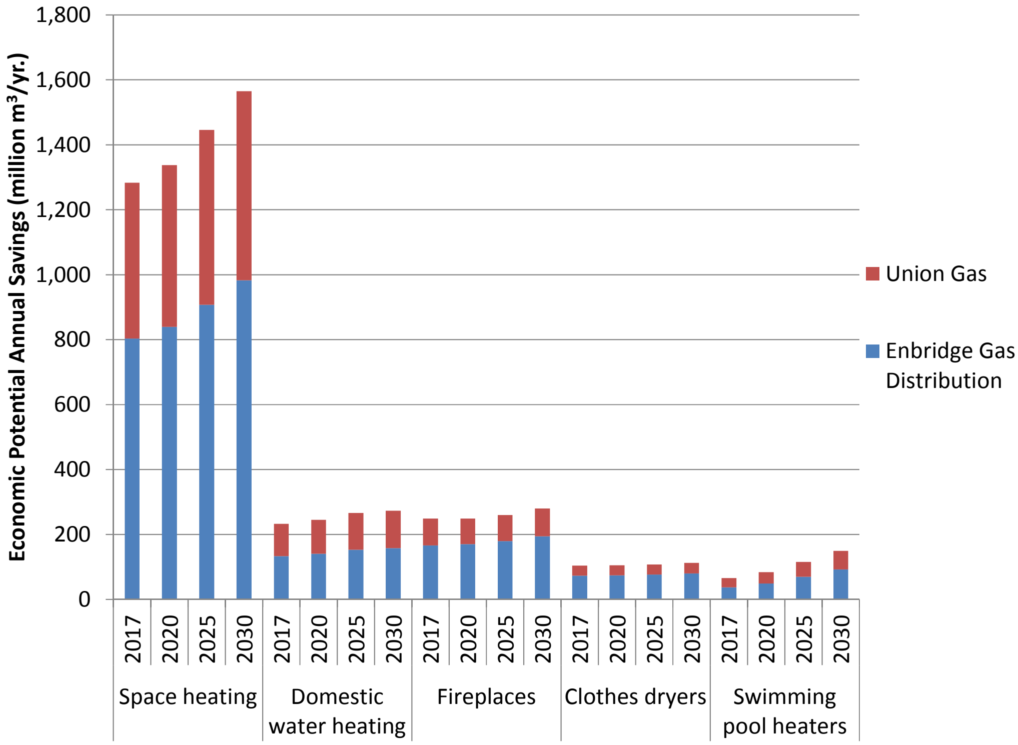


Exhibit 37 Table of Residential Economic Potential Savings by End Use, Year, and Utility

End Use	Milestone Years	Savings (million m^3/yr.)		
		Enbridge Gas Distribution	Union Gas	Total
Space heating	2017	804	480	1,283
	2020	839	498	1,337
	2025	907	539	1,446
	2030	983	582	1,565
Domestic water heating	2017	133	100	233
	2020	140	105	245
	2025	153	113	266
	2030	158	115	273
Fireplaces	2017	166	83	249
	2020	170	79	249
	2025	179	80	260
	2030	194	86	280
Clothes dryers	2017	73	31	104
	2020	74	31	105
	2025	77	31	108
	2030	80	32	112
Swimming pool heaters	2017	37	28	66
	2020	49	35	84
	2025	69	46	116
	2030	92	57	149
Grand Total	2017	1,213	722	1,935
	2020	1,272	748	2,021
	2025	1,386	810	2,195
	2030	1,507	873	2,379

Exhibit 38 Graph of Residential Economic Potential Savings by End Use, Year, and Vintage

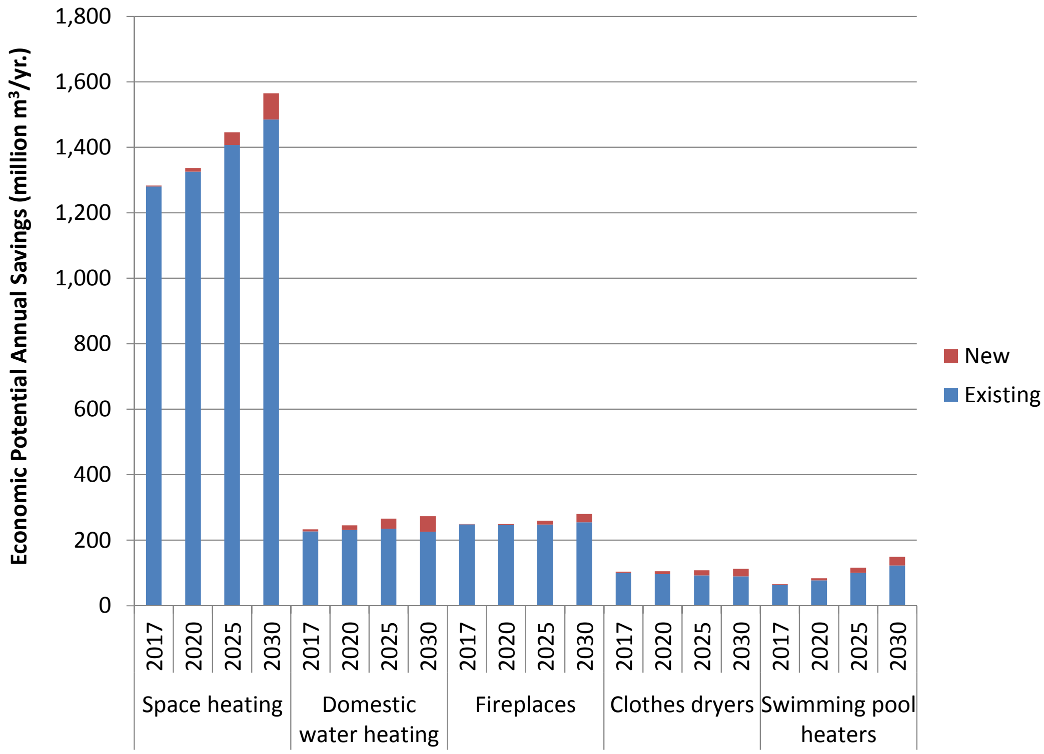


Exhibit 39 Table of Residential Economic Potential Savings by End Use, Year, and Vintage

End Use	Milestone Years	Savings (million m^3/yr.)		
		Existing	New	Total
Space heating	2017	1,280	3	1,283
	2020	1,326	12	1,337
	2025	1,407	39	1,446
	2030	1,485	80	1,565
Domestic water heating	2017	227	6	233
	2020	231	14	245
	2025	236	30	266
	2030	226	47	273
Fireplaces	2017	249	1	249
	2020	246	3	249
	2025	248	12	260
	2030	255	25	280
Clothes dryers	2017	100	4	104
	2020	97	8	105
	2025	92	16	108
	2030	90	23	112
Swimming pool heaters	2017	63	2	66
	2020	78	6	84
	2025	101	15	116
	2030	123	26	149
Grand Total	2017	1,919	16	1,935
	2020	1,977	44	2,021
	2025	2,084	111	2,195
	2030	2,178	201	2,379

4.6 Achievable Potential

This section presents estimates of residential achievable potential based on the methodology discussed in section 2.8.

4.6.1 Summary of Residential Sector Interviews

Ten residential interviews were conducted in order to collect information for the achievable potential scenarios. The following measure categories as primary topics (in each case, other related measures were discussed at the end):

- Building envelope measures, usually starting with wall insulation
- Furnace measures
- New home construction
- Behaviour measures
- Adaptive thermostats
- Domestic hot water (DHW) measures

Interviewees were asked to focus on one target type of dwelling – usually a detached home in the GTA of the appropriate vintage – and then later discuss variations.

4.6.2 Program cost assumptions

The level of incentive required was based on the interviewee conversations, either as a fraction of measure cost or as a payback the customer might require. In the case of the BAU incentives, this information was supplemented by information on the incentive levels used in current Ontario gas utility residential programs, where such programs included the measure being analyzed. For the BAU cases, the ratio of non-incentive to incentive costs was set at 0.5, based on ICF's professional experience in Ontario's residential sector. It is assumed that aggressive programs with higher incentive costs would generally require proportionally less administrative overhead, and would therefore require a lower ratio, so ICF recommended a ratio of 0.3. For measures where no incentive would normally be provided, such as for behavioral measures with no capital cost, ICF used a PAC test ratio to set the program cost, using 2.0 for BAU, and 1.5 for aggressive.

Low-income programs were assumed to have lower PAC test hurdle rates than the other residential programs for the BAU versions of the programs, as these programs are typically subsidized. For the aggressive versions of the measure incentives, the cost between low-income and the other programs were assumed to converge as the remaining barriers to implementation are more similar at these levels of program support. This is based on the assumption that the very high participation goals of the aggressive program versions must ultimately reach the last persuadable customer. It is likely that in either the low-income program or the other residential programs, this last persuadable customer will require the same level of program incentive and other support and may in fact be the same customer.

4.6.3 Program Cost Supply Curves and Achievable Savings

Exhibit 40 presents the supply curves to 2020 for the residential (excluding low-income) achievable potential scenarios. The total estimated cost up to 2020 for the unconstrained achievable potential scenario is $1,298 million, which exceeds both the constrained and semi-constrained budgets for 2020. Therefore, measures that appeared above the budget threshold lines shown in the graphs were excluded from the semi-constrained and constrained scenarios. A portion of the measure savings that straddled the budget lines were included.

Exhibit 41 presents a summary of the residential (excluding low-income) achievable potential savings and estimated costs for each achievable potential scenario in 2020 and in 2030. Semi-constrained and constrained estimated program costs were $318 million and $235 million, respectively for residential (excluding low-income) for 2015-2020. For residential (excluding low-income) in 2020-2030, the semi-constrained and constrained estimated program costs were $844 million and $422 million, respectively. In the residential (excluding low-income) semi-constrained program, the total estimated cost up to 2030 was $1,161 million or 48% of the total estimated spending of the residential (excluding low-income) unconstrained program while the total savings of natural gas were 11,266 million cubic metres or 60% of the total savings of natural gas in the residential (excluding low-income) unconstrained scenario.

In the residential (excluding low-income) constrained program, the total spending up to 2030 was $553 million or 65% of the total spending of the residential (excluding low-income) semi-constrained program while the total savings of natural gas was 7,516 million cubic metres or 67% of the total savings of natural gas in the residential (excluding low-income) semi-constrained program.

For the residential (excluding low-income) semi-constrained program, the average program spending up to both 2020 and 2030 is about $0.10 per cubic metre of measure lifecycle natural gas saved. For the residential (excluding low-income) constrained program, the average program spending up to 2020 is about $0.09 per cubic metre of measure lifecycle natural gas saved.

Exhibit 40 Residential (excluding low-income) Supply Curve: Program Costs for 2015 to 2020

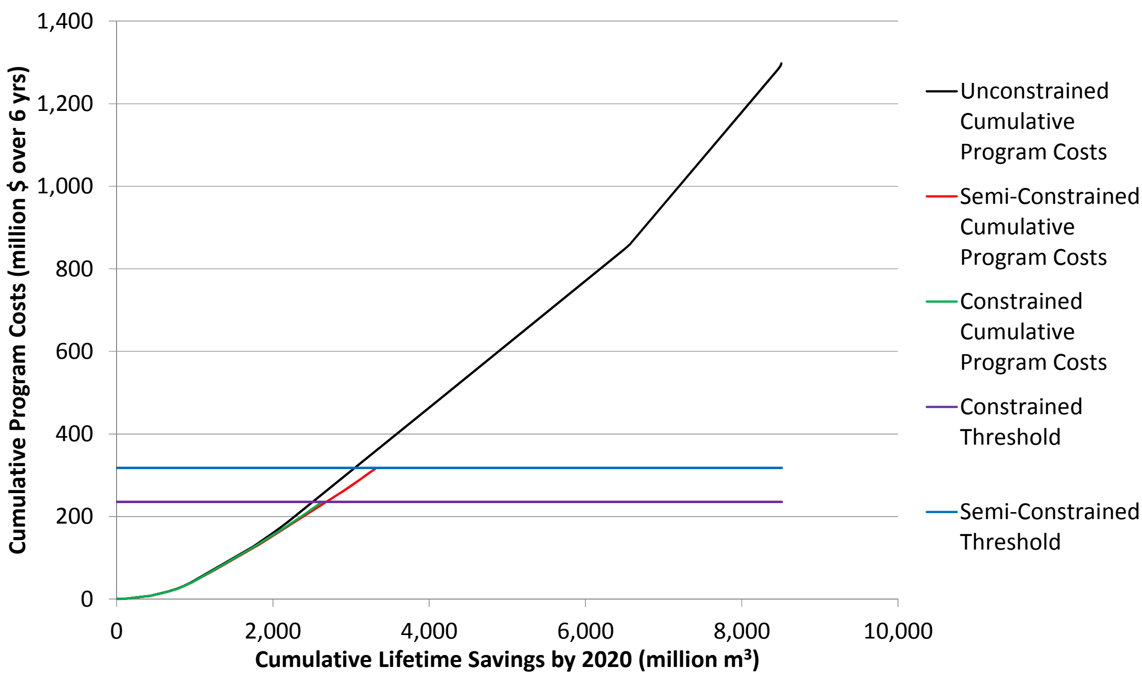


Exhibit 41 Residential (excluding low-income) Achievable Potential Savings and Program Cost Results[64]

Value	Unconstrained		Semi-Constrained		Constrained	
	Year					
	2020	2030	2020	2030	2020	2030
Annual Savings (million m^3/yr.)	503	1,109	330	845	307	553
Measure Lifecycle Savings (million m^3)	8,506	18,675	3,321	11,266	2,629	7,516
Value of Savings (million $)	1,385	3,262	520	1,948	430	1,293
Program Spending to Milestone Year (million $)	1,298*	2,435*	318	1,161	235	657
Average Annual Program Spending (million $/yr.)	216*	152*	53	73	39	41
Average Program Spending up to Milestone Year ($/$m^3$)	0.15*	0.13*	0.10	0.10	0.09	0.09

**Note: These are not specific program costs but are the total costs for the scenario.*

Exhibit 42 presents the supply curves to 2020 for the low-income residential achievable potential scenarios. The total program spending up to 2020 for the unconstrained achievable potential scenarios also exceeds both the constrained and semi-constrained budgets for 2020. Therefore, measures that appeared above the budget threshold lines shown in the graphs were excluded from the semi-constrained and constrained scenarios. A portion of the measure savings that straddled the budget lines were included.

Exhibit 43 presents a summary of the low-income residential sector achievable potential savings and program costs for each achievable potential scenario in 2020 and in 2030. Semi-constrained and constrained program spending were $148 million and $108 million, respectively for low-income in 2015-2020. For low-income residential in 2020-2030, the semi-constrained and constrained program spending were $388 million and $194 million, respectively.

In the low-income residential semi-constrained achievable potential scenario, the total spending up to 2030 was $536 million or 54% of the total spending of the low-income unconstrained achievable potential scenario while the total savings of natural gas was 3,731 million cubic metres or 69% of the total savings of natural gas in the low-income unconstrained achievable potential scenario. In the low-income constrained achievable potential scenario, the total spending up to 2030 was $302 million or 56% of the total spending of the low-income residential semi-constrained achievable potential scenario while the total savings of natural gas was 2,829 million cubic metres or 76% of the total savings of natural gas in the low-income residential semi-constrained program.

For the low-income semi-constrained achievable potential scenario, the average program spending up to 2020 is about $0.15 per cubic metre of measure lifecycle natural gas saved. For the low-income residential constrained program, the average program spending up to 2020 is about $0.13 per cubic metre of measure lifecycle natural gas saved.

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[64] The annual savings represent the natural gas saved each year by measures implemented in the years up to a milestone year.

The measure lifecycle savings present the natural gas saved over the lifetime of the measure installed up to that year, taking into account repeated installation of measures with lifetimes shorter than the period in question.

The value of the savings is the sum of the stream of avoided cost savings over the measure lifecycle for all the measures, with all savings discounted back to the year of installation.

The program spending to milestone year represents the sum of program spending for all years up to a given milestone year without discounting.

The average annual program spending is the total program spending up to a given milestone year divided by the number of years until that milestone year.

The average program spending up to milestone year is the total program spending divided by the total measure lifecycle savings.

Exhibit 42 Low-Income Residential Supply Curve: Program Costs for 2015 to 2020

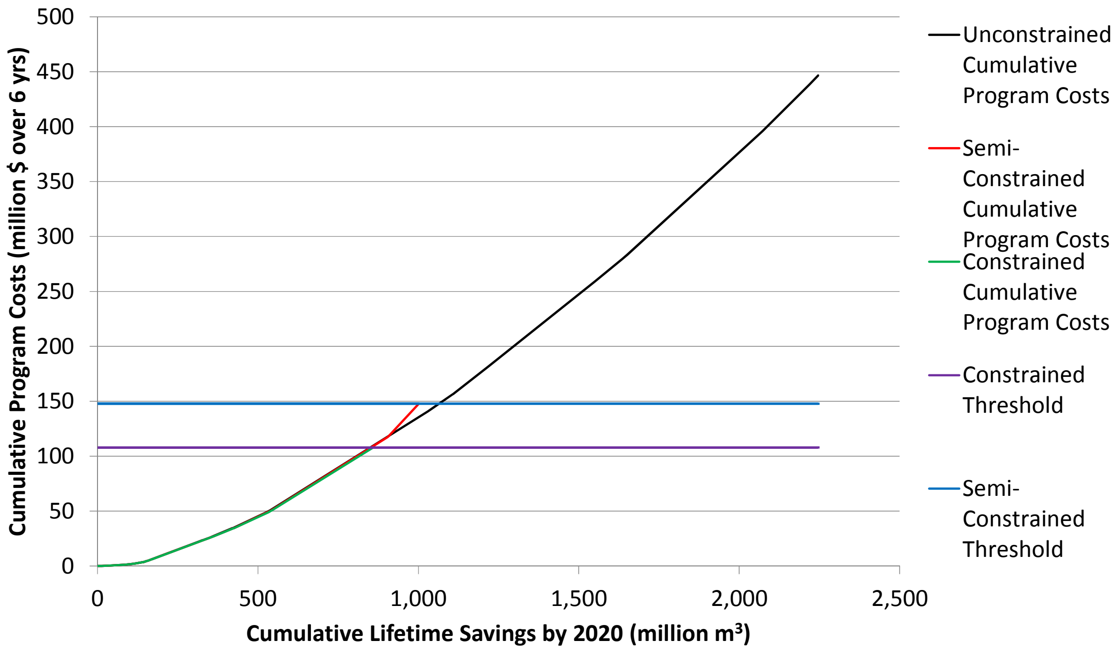


Exhibit 43 Low-Income Residential Achievable Potential Savings and Program Cost Results[65]

Value	Unconstrained		Semi-Constrained		Constrained	
	Year					
	2020	2030	2020	2030	2020	2030
Annual Savings (million m^3/yr.)	205	430	93	260	88	221
Measure Lifecycle Savings (million m^3)	2,246	5,399	1,002	3,731	859	2,829
Value of Savings (million $)	434	1,063	208	743	173	536
Program Spending to Milestone Year (million $)	447*	999*	148	536	108	302
Average Annual Program Spending (million $/yr.)	74*	62*	25	33	18	19
Average Program Spending up to Milestone Year ($/$m^3$)	0.20*	0.19*	0.15	0.14	0.13	0.11

**Note: These are not specific program costs but are the total costs for the scenario.*

65 See footnote 64 for details on the values in this table.

4.6.4 Achievable Potential Summary – All Scenarios

Exhibit 44 and Exhibit 45 present a comparison of the reference case, technical, economic, unconstrained, constrained, and semi-constrained achievable potential consumption for the residential sector. The unconstrained, semi-constrained, and constrained achievable potential scenarios could potentially reduce residential consumption by 8.7%, 5.2%, and 4.9%, respectively, relative to commercial reference case consumption, by 2020, and by 17.3%, 12.4%, and 8.7%, respectively, relative to commercial reference case consumption, by 2030.

Exhibit 44 Residential Reference, Technical Potential, Economic Potential, and Achievable Potential Scenario Annual Consumption

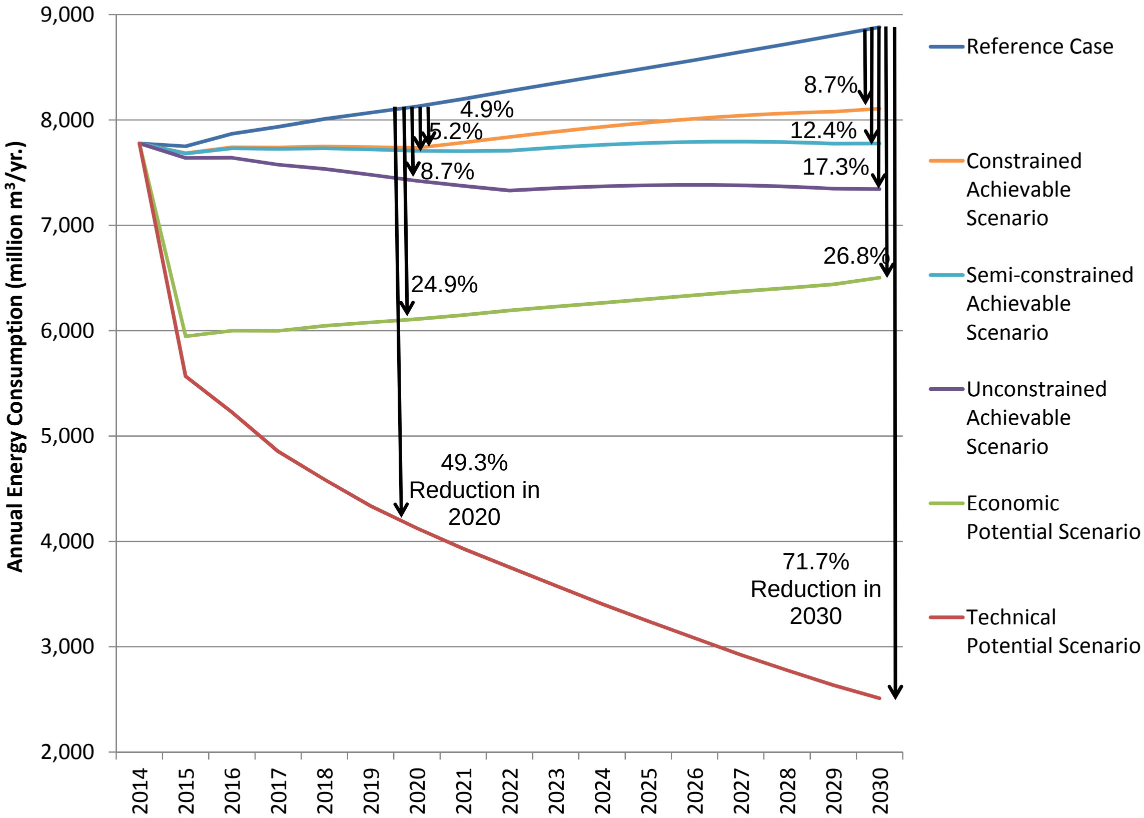


Exhibit 45 Residential Reference, Technical Potential, Economic Potential, and Achievable Potential Scenario Annual Savings Relative to Reference Case

Year	Reference Case Use (million m³/yr.)	Technical Potential		Economic Potential		Unconstrained Achievable Potential		Semi-constrained Achievable Potential		Constrained Achievable Potential	
		Absolute Savings (million m³/yr.)	Savings Relative to Reference Case (%)	Absolute Savings (million m³/yr.)	Relative to Reference Case (%)	Absolute Savings (million m³/yr.)	Relative to Reference Case (%)	Absolute Savings (million m³/yr.)	Relative to Reference Case (%)	Absolute Savings (million m³/yr.)	Relative to Reference Case (%)
2015	7,751	2,185	28.2%	1,805	23.3%	110	1.4%	69	0.9%	65	0.8%
2016	7,871	2,643	33.6%	1,870	23.8%	230	2.9%	138	1.8%	130	1.6%
2017	7,934	3,079	38.8%	1,935	24.4%	357	4.5%	207	2.6%	194	2.4%
2018	8,009	3,422	42.7%	1,962	24.5%	474	5.9%	277	3.5%	260	3.2%
2019	8,070	3,735	46.3%	1,991	24.7%	590	7.3%	349	4.3%	326	4.0%
2020	8,130	4,006	49.3%	2,021	24.9%	708	8.7%	423	5.2%	395	4.9%
2025	8,496	5,253	61.8%	2,195	25.8%	1,115	13.1%	714	8.4%	519	6.1%
2030	8,882	6,371	71.7%	2,379	26.8%	1,539	17.3%	1,105	12.4%	774	8.7%

4.6.5 Achievable Potential – Unconstrained Scenario

As was shown in Exhibit 45, the total unconstrained achievable potential scenario in the residential sector results in natural savings of 708 million cubic metres by 2020, or 8.7% of 2020 residential reference case consumption, and 1,539 million cubic metres by 2030, or 17.3% of 2030 residential reference case consumption. The remainder of this section provides a breakdown of the residential unconstrained achievable potential results.

As shown in Exhibit 46 and Exhibit 47, single detached homes (excluding low-income) account for nearly 60% (422 million cubic metres) of residential unconstrained achievable savings potential by 2020, while the attached homes (excluding low-income) account for 10% (74 million cubic metres) by 2020. Low-income residential homes account for about 29% (205 million cubic metres) of residential unconstrained achievable savings potential by 2020. Mobile homes account for 1% (7 million cubic metres) of residential unconstrained achievable savings potential by 2020. By 2030, the distribution of savings between the sub-sectors remains relatively consistent from 2020.

Space heating accounts for nearly 91% (644 million cubic metres) of residential unconstrained achievable savings potential by 2020, and DWH and fireplaces each account for 2% (17 million cubic metres), clothes dryers accounting for 3% (20 million cubic metres), and swimming pool heaters accounting for about 1% (10 million cubic metres). By 2030, the distribution of the savings shifted slightly from space heating to the other end uses. By 2030, the space heating accounted for nearly 78% (1,206 million cubic metres) of residential unconstrained achievable savings potential, with DWH accounting for 4% (63 million cubic metres), fireplaces accounting for 10% (149 million cubic metres), clothes dryers accounting for 4% (56 million cubic metres), and swimming pool heaters accounting for about 4% (63 million cubic metres).

Exhibit 46 Graph of Residential Unconstrained Achievable Potential Savings by Use, Year, and Sub-Sector

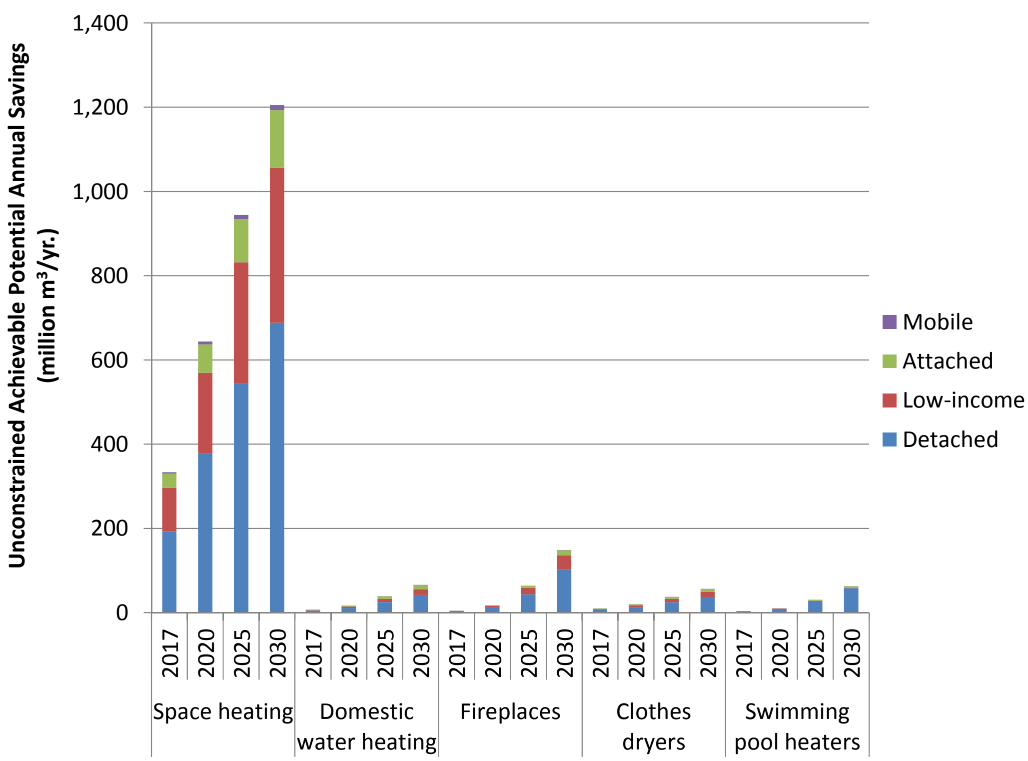


Exhibit 47 Table of Residential Unconstrained Achievable Potential Savings by Use, Year, and Sub-Sector

End Use	Milestone Years	Savings (million m^3/yr.)				
		Detached	Low-income	Attached	Mobile	Total
Space heating	2017	193	103	34	3	333
	2020	377	192	68	7	644
	2025	544	288	102	10	944
	2030	688	368	137	13	1,206
Domestic water heating	2017	5	2	1	0	7
	2020	11	4	2	0	17
	2025	25	8	5	0	39
	2030	42	14	10	1	66
Fireplaces	2017	3	1	0	0	4
	2020	12	4	1	0	17
	2025	43	16	5	0	64
	2030	102	35	12	1	149
Clothes dryers	2017	7	2	1	0	10
	2020	13	4	2	0	20
	2025	25	8	4	0	37
	2030	37	12	7	0	56
Swimming pool heaters	2017	3	0	0	0	3
	2020	9	0	1	0	10
	2025	28	1	2	0	30
	2030	58	1	3	0	63
Grand Total	2017	210	108	36	3	357
	2020	422	205	74	7	708
	2025	665	320	119	11	1,115
	2030	927	430	168	14	1,539

As shown in Exhibit 48 and Exhibit 49, dwellings in Enbridge Gas Distribution's service territory accounted for approximately 63% (442 million cubic metres) of the residential unconstrained achievable savings potential by 2020, with dwellings in Union Gas' service territory accounting for the remainder (265 million cubic metres). By 2030, the distribution of savings between the utilities remained the same.

As shown in Exhibit 50 and Exhibit 51, existing homes accounted for approximately 99% (702 million cubic metres) of the residential unconstrained achievable savings potential by 2020, with new homes accounting for the remainder (6 million cubic metres). By 2030, the distribution of savings slightly shifts with existing homes accounted for approximately 94% (1,442 million cubic metres) of the residential unconstrained achievable savings potential, with new homes accounting for the remainder (97 million cubic metres).

Exhibit 48 Graph of Residential Unconstrained Achievable Potential Savings by Use, Year, and Utility

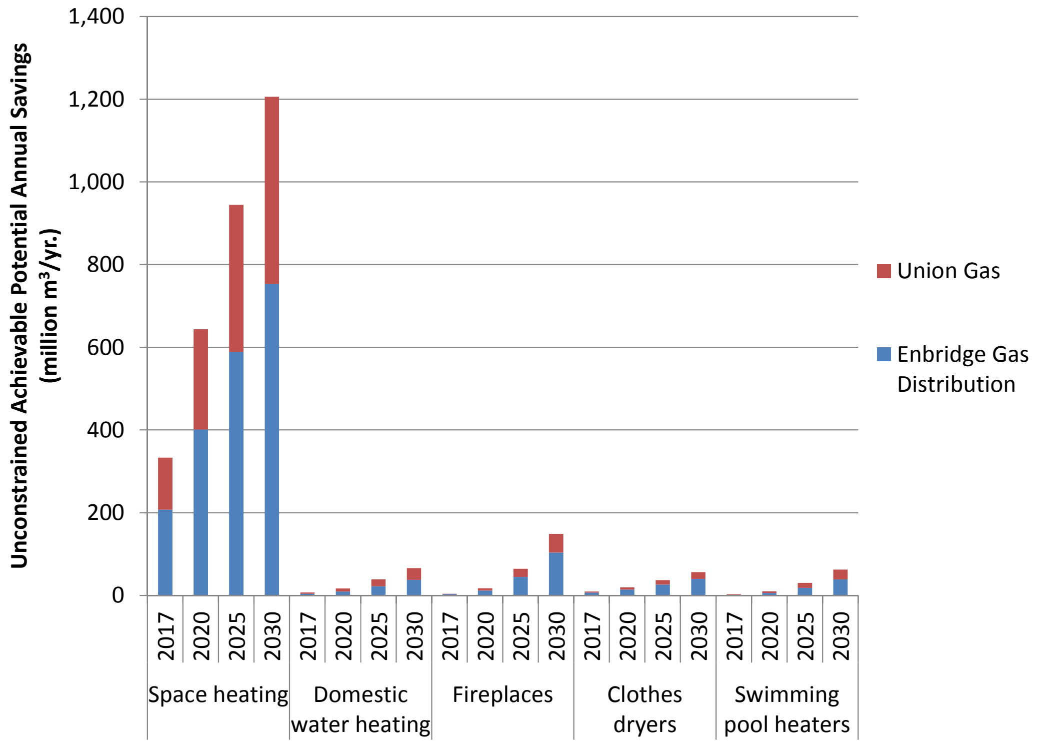


Exhibit 49 Table of Residential Unconstrained Achievable Potential Savings by Use, Year, and Utility

End Use	Milestone Years	Savings (million m^3/yr.)		
		Enbridge Gas Distribution	Union Gas	Total
Space heating	2017	207	126	333
	2020	401	243	644
	2025	588	356	944
	2030	752	453	1,206
Domestic water heating	2017	4	3	7
	2020	10	7	17
	2025	22	17	39
	2030	38	28	66
Fireplaces	2017	3	1	4
	2020	12	5	17
	2025	44	20	64
	2030	103	45	149
Clothes dryers	2017	7	3	10
	2020	14	6	20
	2025	26	11	37
	2030	40	16	56
Swimming pool heaters	2017	2	1	3
	2020	6	4	10
	2025	18	12	30
	2030	39	24	63
Grand Total	2017	223	135	357
	2020	442	265	708
	2025	700	415	1,115
	2030	973	566	1,539

Exhibit 50 Graph of Residential Unconstrained Achievable Potential Savings by Use, Year, and Vintage

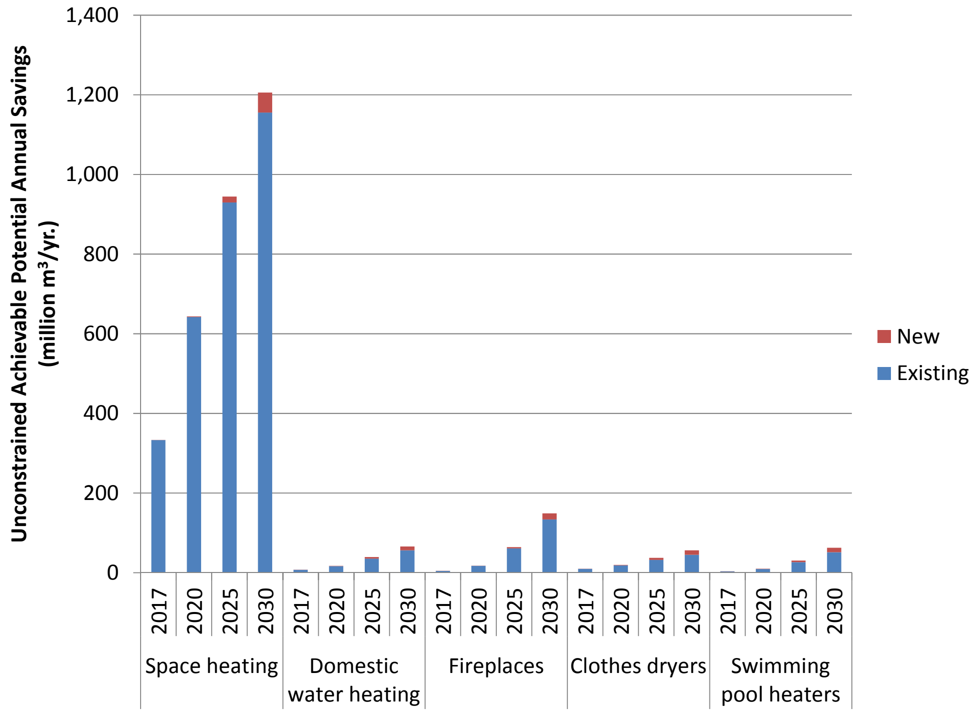


Exhibit 51 Table of Residential Unconstrained Achievable Potential Savings by Use, Year, and Vintage

End Use	Milestone Years	Savings (million m³/yr.)		
		Existing	New	Total
Space heating	2017	333	0	333
	2020	642	2	644
	2025	929	15	944
	2030	1,156	50	1,206
Domestic water heating	2017	7	0	7
	2020	16	1	17
	2025	35	4	39
	2030	56	10	66
Fireplaces	2017	4	0	4
	2020	17	0	17
	2025	61	3	64
	2030	134	15	149
Clothes dryers	2017	9	0	10
	2020	18	2	20
	2025	32	5	37
	2030	45	11	56
Swimming pool heaters	2017	3	0	3
	2020	9	1	10
	2025	26	4	30
	2030	51	11	63
Grand Total	2017	356	1	357
	2020	702	6	708
	2025	1,083	31	1,115
	2030	1,442	97	1,539

4.6.6 Achievable Potential – Semi-constrained Scenario

As was shown in Exhibit 45, the total semi-constrained achievable potential scenario in the residential sector results in natural savings of 423 million cubic metres by 2020, or 5.2% of 2020 residential reference case consumption, and 1,105 million cubic metres by 2030, or 12.4% of 2030 residential reference case consumption. The remainder of this section provides a breakdown of the residential semi-constrained achievable potential results.

As shown in Exhibit 52 and Exhibit 53, income single detached homes (excluding low-income) account for nearly 65% (275 million cubic metres) of residential semi-constrained achievable savings potential by 2020, while the attached homes (excluding low-income) account for 12% (49 million cubic metres) by 2020. Low-income homes account for about 22% (93 million cubic metres) of residential semi-constrained achievable savings potential by 2020. Mobile homes account for 1% (5 million cubic metres) of residential semi-constrained achievable savings potential by 2020. By 2030, the distribution of savings between the sub-sectors remains relatively consistent from 2020.

Space heating accounts for nearly 86% (365 million cubic metres) of total residential semi-constrained achievable savings potential by 2020, DWH accounts for 4% (17 million cubic metres), fireplaces account for 3% (11 million cubic metres), clothes dryers account for 5% (20 million cubic metres), and swimming pool heaters account for about 2% (10 million cubic metres). Similar to the unconstrained achievable potential scenario, by 2030, the distribution of the savings shifted slightly from space heating to the other end uses. By 2030, the space heating accounts for nearly 73% (801 million cubic metres) of residential semi-constrained achievable savings potential, DWH accounts for 6% (62 million cubic metres), fireplaces account for 11% (123 million cubic metres), clothes dryers account for 5% (56 million cubic metres), and swimming pool heaters account for about 6% (63 million cubic metres).

As shown in Exhibit 54 and Exhibit 55, the distribution of the semi-constrained achievable savings potential remains the same as the distribution of the unconstrained achievable savings potential with dwellings in Enbridge Gas Distribution's service territory accounting for approximately 63% (264 million cubic metres) of the residential semi-constrained achievable savings potential by 2020 and dwellings in Union Gas' service territory accounting for 37% (265 million cubic metres). The distribution of savings between the utilities remains consistent until 2030.

As shown in Exhibit 56 and Exhibit 57, similar to the unconstrained achievable potential scenario, existing homes accounted for approximately 99% (418 million cubic metres) of the residential semi-constrained achievable savings potential by 2020, with new homes accounting for the remainder (4 million cubic metres). By 2030, the distribution of savings slightly shifts with existing homes accounted for approximately 93% (1,031 million cubic metres) of the residential semi-constrained achievable savings potential, with new homes accounting for the remainder (74 million cubic metres).

Exhibit 52 Graph of Residential Semi-Constrained Achievable Potential Savings by Use, Year, and Sub-Sector

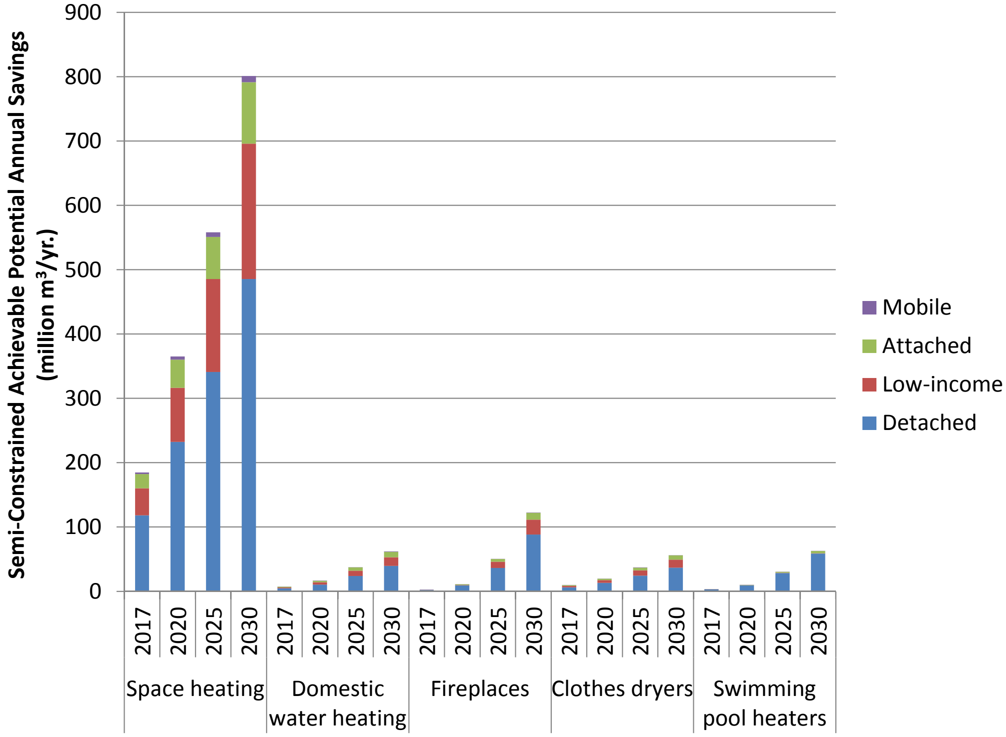


Exhibit 53 Table of Residential Semi-Constrained Achievable Potential Savings by Use, Year, and Sub-Sector

End Use	Milestone Years	Savings (million m^3/yr.)				
		Detached	Low-income	Attached	Mobile	Total
Space heating	2017	118	42	22	3	185
	2020	232	84	44	5	365
	2025	341	145	65	7	558
	2030	486	210	96	10	801
Domestic water heating	2017	5	2	1	0	7
	2020	11	4	2	0	17
	2025	24	8	5	0	38
	2030	39	14	9	1	62
Fireplaces	2017	2	0	0	0	2
	2020	9	1	1	0	11
	2025	36	10	4	0	50
	2030	88	23	11	1	123
Clothes dryers	2017	7	2	1	0	10
	2020	13	4	2	0	20
	2025	25	8	4	0	37
	2030	37	12	7	0	56
Swimming pool heaters	2017	3	0	0	0	3
	2020	9	0	1	0	10
	2025	29	0	2	0	31
	2030	59	1	3	0	63
Grand Total	2017	134	46	24	3	207
	2020	275	93	49	5	423
	2025	455	171	80	8	714
	2030	709	260	125	11	1,105

Exhibit 54 Graph of Residential Semi-Constrained Achievable Potential Savings by Use, Year, and Utility

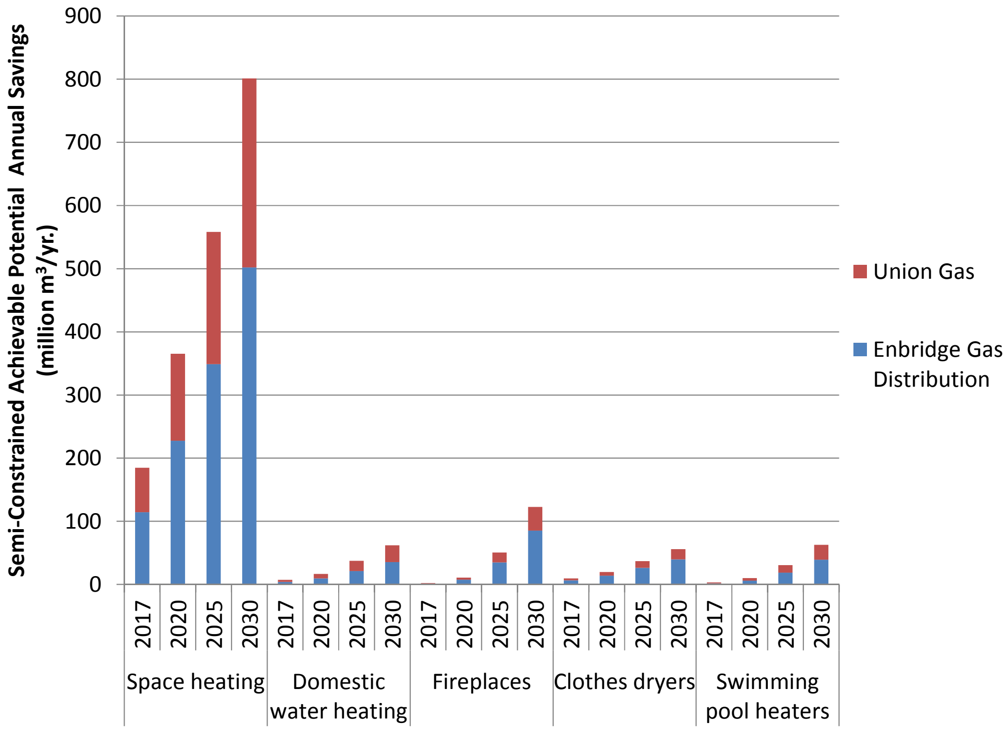


Exhibit 55 Table of Residential Semi-Constrained Achievable Potential Savings by Use, Year, and Utility

End Use	Milestone Years	Savings (million m^3/yr.)		
		Enbridge Gas Distribution	Union Gas	Total
Space heating	2017	115	70	185
	2020	227	138	365
	2025	349	209	558
	2030	502	299	801
Domestic water heating	2017	4	3	7
	2020	10	7	17
	2025	22	16	38
	2030	36	26	62
Fireplaces	2017	2	1	2
	2020	7	3	11
	2025	35	16	50
	2030	85	37	123
Clothes dryers	2017	7	3	10
	2020	14	6	20
	2025	26	11	37
	2030	40	16	56
Swimming pool heaters	2017	2	1	3
	2020	6	4	10
	2025	19	12	31
	2030	39	24	63
Grand Total	2017	129	78	207
	2020	264	158	423
	2025	450	263	714
	2030	702	403	1,105

Exhibit 56 Graph of Residential Semi-Constrained Achievable Potential Savings by Use, Year, and Vintage

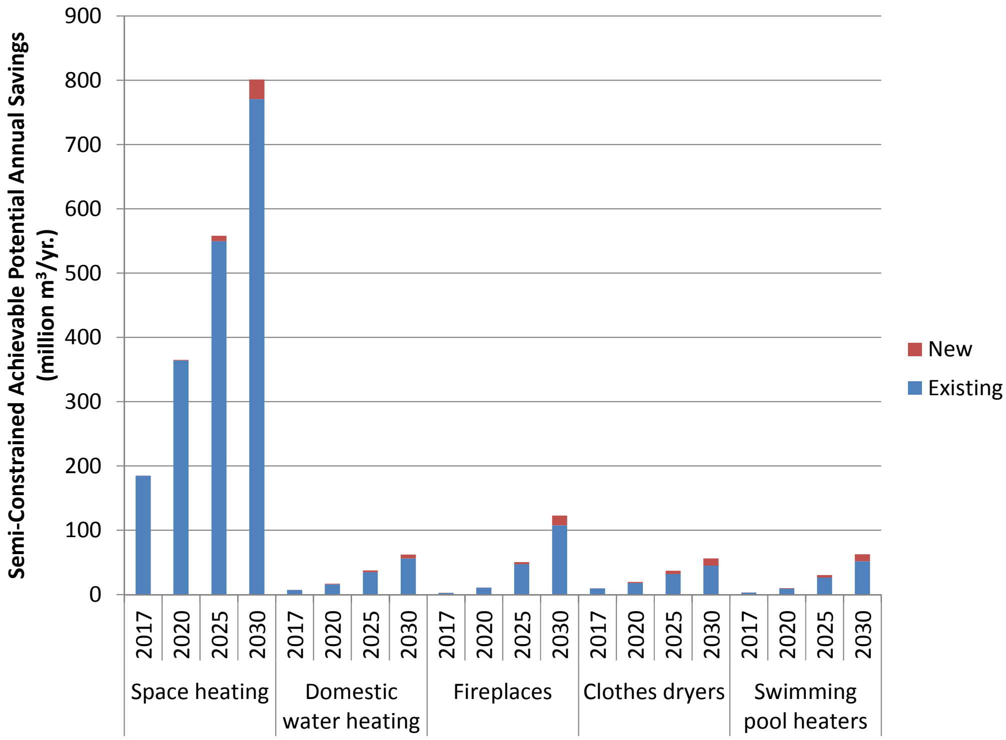


Exhibit 57 Table of Residential Semi-Constrained Achievable Potential Savings by Use, Year, and Vintage

End Use	Milestone Years	Savings (million m^3/yr.)		
		Existing	New	Total
Space heating	2017	185	0	185
	2020	364	1	365
	2025	550	9	558
	2030	771	30	801
Domestic water heating	2017	7	0	7
	2020	16	1	17
	2025	35	3	38
	2030	56	6	62
Fireplaces	2017	2	0	2
	2020	11	0	11
	2025	47	3	50
	2030	108	15	123
Clothes dryers	2017	9	0	10
	2020	18	2	20
	2025	32	5	37
	2030	45	11	56
Swimming pool heaters	2017	3	0	3
	2020	9	1	10
	2025	27	4	31
	2030	52	11	63
Grand Total	2017	207	1	207
	2020	418	4	423
	2025	690	24	714
	2030	1,031	74	1,105

4.6.7 Achievable Potential – Constrained Scenario

As was shown in Exhibit 45, the total constrained achievable potential scenario in the residential sector results in natural savings of 395 million cubic metres by 2020, or 4.9% of 2020 residential reference case consumption, and 774 million cubic metres by 2030, or 8.7% of 2030 residential reference case consumption. The remainder of this section provides a breakdown of the residential constrained achievable potential results.

As shown in Exhibit 58 and Exhibit 59, single detached homes (excluding low-income) account for nearly 66% (256 million cubic metres) of residential constrained achievable savings potential by 2020, while the attached homes (excluding low-income) account for 12% (46 million cubic metres) by 2020. Low-income homes account for about 22% (88 million cubic metres) of residential semi-constrained achievable savings potential by 2020. Mobile homes account for 1% (5 million cubic metres) of residential constrained achievable savings potential by 2020. By 2030, the distribution of savings shifts slightly from non-low-income homes to low-income homes. Single detached homes (excluding low-income) account for nearly 60% (462 million cubic metres) of residential constrained achievable savings potential by 2030, while attached homes (excluding low-income) account for 11% (83 million cubic metres) by 2030. Low-income homes account for about 29% (221 million cubic metres) of residential semi-constrained achievable savings potential by 2030.

Space heating accounted for nearly 86% (338 million cubic metres) of residential semi-constrained achievable savings potential by 2020, DWH accounts for 4% (17 million cubic metres), fireplaces account for 3% (11 million cubic metres), clothes dryers accounting for 5% (20 million cubic metres), and swimming pool heaters account for about 2% (10 million cubic metres). Similar to the unconstrained and semi-constrained scenarios, by 2030, the distribution of the savings shifted slightly from space heating to the other end uses. By 2030, the space heating accounted for nearly 76% (591 million cubic metres) of residential constrained achievable savings potential, DWH accounts for 7% (53 million cubic metres), fireplaces account for 7% (58 million cubic metres), clothes dryers account for 7% (56 million cubic metres), and swimming pool heaters account for about 2% (17 million cubic metres).

As shown in Exhibit 60 and Exhibit 61, the distribution of the constrained achievable savings potential remained the same as the distribution of the unconstrained and semi-constrained scenarios, with dwellings in Enbridge Gas Distribution's service territory accounting for approximately 63% (247 million cubic metres) of the residential constrained achievable savings potential by 2020 and dwellings in Union Gas' service territory accounting for 37% (149 million cubic metres). By 2030, the distribution of savings between the utilities relatively consistent from 2020.

As shown in Exhibit 62 and Exhibit 63, similar to the unconstrained and semi-constrained achievable potential scenarios, existing homes accounted for approximately 99% (391 million cubic metres) of the residential constrained achievable savings potential by 2020, with new homes accounting for the remainder (4 million cubic metres). By 2030, the distribution of savings slightly shifts with existing homes accounted for approximately 95% (735 million cubic metres) of the residential semi-constrained achievable savings potential, with new homes accounting for the remainder (39 million cubic metres).

Exhibit 58 Residential Constrained Achievable Potential Savings by Use, Year, and Sub-Sector

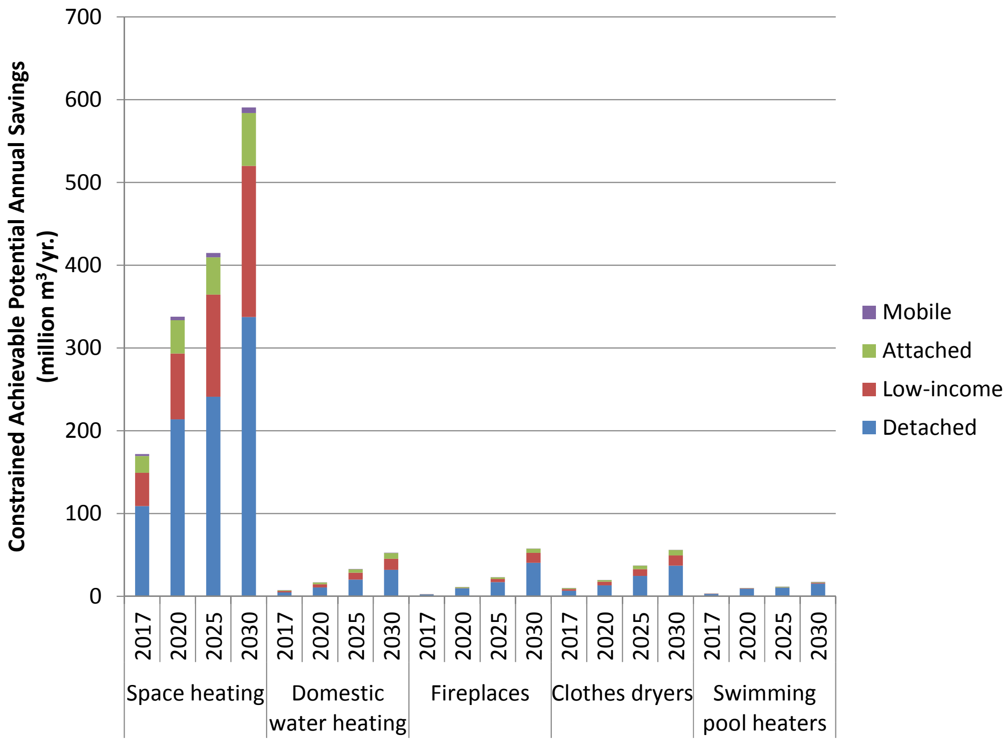


Exhibit 59 Table of Residential Constrained Achievable Potential Savings by Use, Year, and Sub-Sector

End Use	Milestone Years	Savings (million m³/yr.)				
		Detached	Low-income	Attached	Mobile	Total
Space heating	2017	109	40	20	2	172
	2020	214	80	40	4	338
	2025	241	123	45	5	415
	2030	337	183	64	7	591
Domestic water heating	2017	5	2	1	0	7
	2020	11	4	2	0	17
	2025	20	8	4	0	33
	2030	32	14	7	0	53
Fireplaces	2017	2	0	0	0	2
	2020	9	1	1	0	11
	2025	17	4	2	0	23
	2030	40	12	5	0	58
Clothes dryers	2017	7	2	1	0	10
	2020	13	4	2	0	20
	2025	25	8	4	0	37
	2030	37	12	7	0	56
Swimming pool heaters	2017	3	0	0	0	3
	2020	9	0	1	0	10
	2025	10	0	1	0	11
	2030	15	1	1	0	17
Grand Total	2017	125	44	23	2	194
	2020	256	88	46	5	395
	2025	313	144	56	6	519
	2030	462	221	83	8	774

Exhibit 60 Graph of Residential Constrained Achievable Potential Savings by Use, Year, and Utility

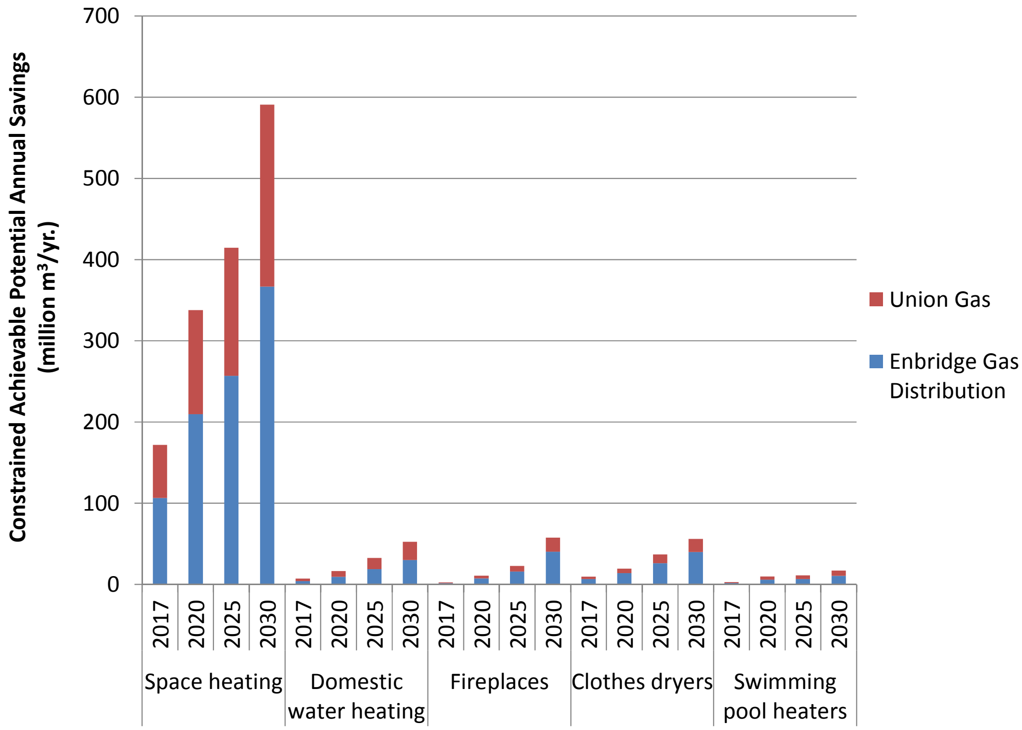


Exhibit 61 Table of Residential Constrained Achievable Potential Savings by Use, Year, and Utility

End Use	Milestone Years	Savings (million m^3/yr.)		
		Enbridge Gas Distribution	Union Gas	Total
Space heating	2017	106	65	172
	2020	210	128	338
	2025	257	158	415
	2030	367	224	591
Domestic water heating	2017	4	3	7
	2020	10	7	17
	2025	19	14	33
	2030	30	22	53
Fireplaces	2017	2	1	2
	2020	7	3	11
	2025	16	7	23
	2030	41	17	58
Clothes dryers	2017	7	3	10
	2020	14	6	20
	2025	26	11	37
	2030	40	16	56
Swimming pool heaters	2017	2	1	3
	2020	6	4	10
	2025	7	5	11
	2030	11	7	17
Grand Total	2017	121	73	194
	2020	247	149	395
	2025	325	194	519
	2030	488	286	774

Exhibit 62 Graph of Residential Constrained Achievable Potential Savings by Use, Year, and Vintage

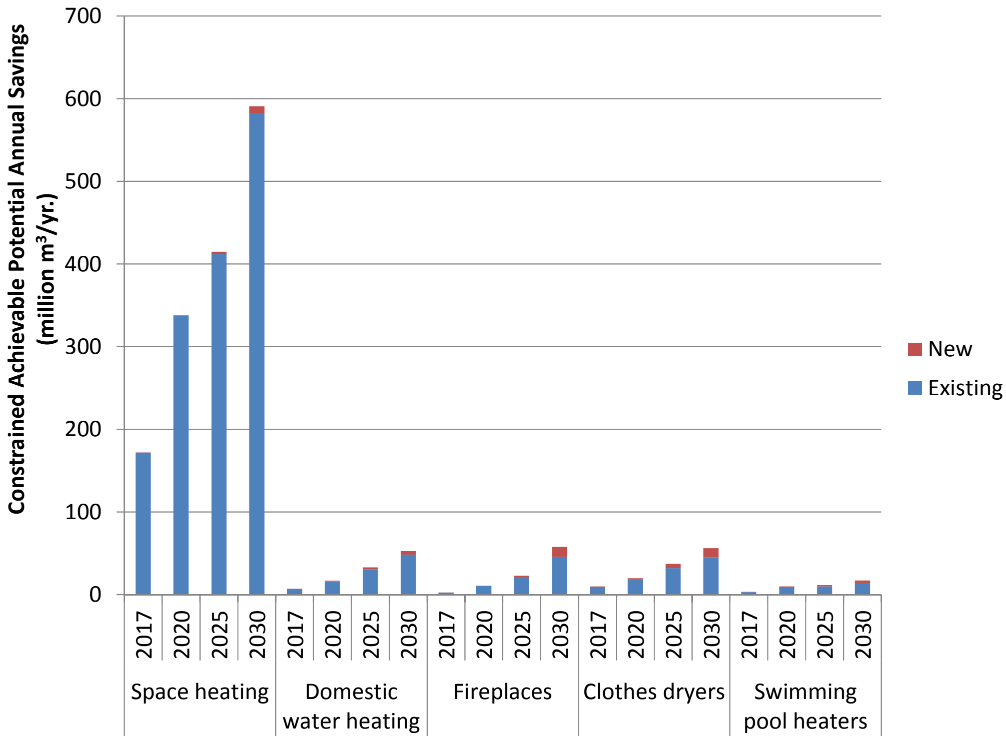


Exhibit 63 Table of Residential Constrained Achievable Potential Savings by Use, Year, and Vintage

End Use	Milestone Years	Savings (million m^3/yr.)		
		Existing	New	Total
Space heating	2017	172	0	172
	2020	337	1	338
	2025	412	3	415
	2030	582	9	591
Domestic water heating	2017	7	0	7
	2020	16	1	17
	2025	31	2	33
	2030	48	4	53
Fireplaces	2017	2	0	2
	2020	11	0	11
	2025	20	3	23
	2030	46	12	58
Clothes dryers	2017	9	0	10
	2020	18	2	20
	2025	32	5	37
	2030	45	11	56
Swimming pool heaters	2017	3	0	3
	2020	9	1	10
	2025	10	1	11
	2030	14	3	17
Grand Total	2017	193	1	194
	2020	391	4	395
	2025	504	14	519
	2030	735	39	774

4.7 GHG Emission Reductions

The residential sector GHG emission reductions, which were calculated according to the methodology presented in section 2.9, are presented in Exhibit 65. The results show that the economic potential GHG emission reductions range from 3,765 million kg CO_2 in 2020 to 4,433 million kg CO_2 in 2030. The unconstrained achievable potential GHG emission reductions range from 1,318 million kg CO_2 in 2020 to 2,867 million kg CO_2 in 2030.

Exhibit 64 Residential GHG Emission Reductions

Year	Reference Case Emissions (million kg CO_2/yr)	Technical Potential		Economic Potential		Unconstrained Achievable Potential		Semi-constrained Achievable Potential		Constrained Achievable Potential	
		GHG Reduction (million kg CO_2/yr.)	Savings Relative to Reference Case (%)	GHG Reduction (million kg CO_2/yr.)	Savings Relative to Reference Case (%)	GHG Reduction (million kg CO_2/yr.)	Savings Relative to Reference Case (%)	GHG Reduction (million kg CO_2/yr.)	Savings Relative to Reference Case (%)	GHG Reduction (million kg CO_2/yr.)	Savings Relative to Reference Case (%)
2015	14,440	4,070	28.2%	3,362	23.3%	206	1.4%	129	0.9%	121	0.8%
2016	14,663	4,924	33.6%	3,483	23.8%	428	2.9%	258	1.8%	241	1.6%
2017	14,782	5,736	38.8%	3,606	24.4%	666	4.5%	386	2.6%	362	2.4%
2018	14,922	6,374	42.7%	3,656	24.5%	883	5.9%	517	3.5%	483	3.2%
2019	15,035	6,957	46.3%	3,709	24.7%	1,100	7.3%	650	4.3%	608	4.0%
2020	15,146	7,463	49.3%	3,765	24.9%	1,318	8.7%	787	5.2%	736	4.9%
2025	15,828	9,787	61.8%	4,090	25.8%	2,077	13.1%	1,330	8.4%	967	6.1%
2030	16,548	11,870	71.7%	4,433	26.8%	2,867	17.3%	2,059	12.4%	1,442	8.7%

4.8 Sensitivity Analysis

This section presents the results of the residential sensitivity analysis based on the methodology discussed in section 2.10.

As shown in Exhibit 65, the increase in avoided costs results in more measures passing the TRC-plus test. Increasing the avoided costs by 50% increases the economic potential savings by 23% in 2020 and 27% in 2030. It also increases the unconstrained achievable potential savings by 34% in 2020 and 32% in 2030. The additional measures were relatively expensive compared to the measures that were already part of the original achievable constrained and semi-constrained scenarios. Therefore, any of the measures that were already part of the original achievable constrained and semi-constrained scenarios were not displaced, because savings from these scenarios are limited by the same constrained and semi-constrained budgets as in the default assumptions case.

The results in Exhibit 65 also show that a 20% increase in participation rates increases all the unconstrained and constrained achievable potential scenario savings results by 6% in 2020, while the semi-constrained achievable potential scenario savings increased by 5%. In 2030, the annual savings increases by 8%, 3%, and 2%, for the unconstrained, semi-constrained and constrained achievable potential scenarios, respectively.

Exhibit 65 Residential Sensitivity Analysis Results

Scenario	Annual Savings (million m^3)		Avoided Cost - 50% Increase				20% Participation Sensitivity			
			Annual Savings (million m^3)		% Change		Annual Savings (million m^3)		% Change	
	2020	2030	2020	2030	2020	2030	2020	2030	2020	2030
Economic Potential	2,021	2,379	2,493	3,029	23%	27%				
Unconstrained Potential	708	1,539	946	2,039	34%	32%	753	1,661	6%	8%
Semi-Constrained Potential	423	1,105					445	1,139	5%	3%
Constrained Potential	395	774					417	789	6%	2%

The results in Exhibit 65 indicate that savings potential is more sensitive to changes in the avoided costs. Since payback, and therefore incentives, are based on retail rates for the residential sector, no change was observed in the constrained or semi-constrained achievable potential scenarios. The results in Exhibit 65 also indicate that savings potential is less sensitive to participation especially when the program spending budget is constrained or semi-constrained.

5 Commercial Sector

5.1 Measure Potential Savings

This chapter describes the commercial measure potential savings using the methodology outlined in section 2.1 of the methodology chapter.

Exhibit 66 presents the maximum potential savings associated with each measure on an individual basis at the maximum possible rate of adoption with colour-coding to differentiate those measures whose average TRC-plus ratio is greater than 1.0 versus less than 1.0. As was previously noted, a TRC-plus ratio that is greater than 1.0 indicates that a measure is economic, from the society resource use perspective.

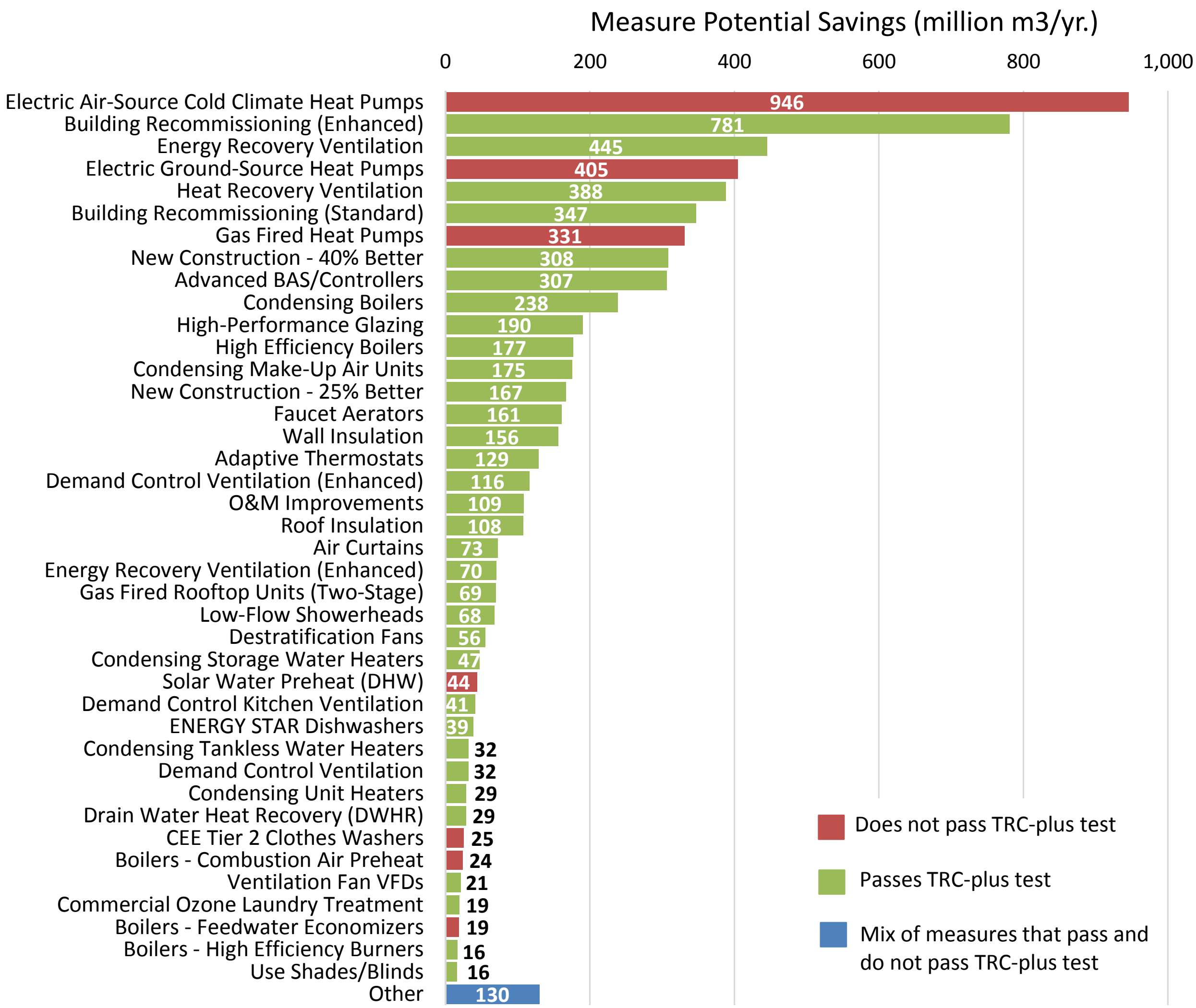
In all cases, the measure savings are calculated relative to a reference case that includes natural changes in the building stock, but these savings do not account for the potential interactive effects with any other measure in the chart, or that some measures will compete with others, depending on customer preferences. These interactive effects will be taken into account in the analysis of technical, economic, and achievable potentials in later chapters, but maximum savings are shown here for the reader's reference. The savings potential of each measure are adjusted appropriately in determining the Ontario-wide technical potential savings.

Exhibit 67 presents results of a financial assessment of each measure. The TRC-plus column presents the benefit/cost ratio for each measure based on the TRC-plus test described previously[66]. The TRC-plus test is performed separately for each sub-sector and region, often with varying assumptions for costs and savings. Where this results in a range of TRC-plus ratios, the range is presented in the table. Where a single number is presented, that means the TRC-plus ratios did not vary significantly. For measures with a TRC-plus over 1.0 in some sub-sectors, the model applies the measure in those sub-sectors, but not in the sub-sectors where the ratio is below 1.0. In the case of low-income buildings, the threshold ratio of 0.7 is used. This test is also repeated in each year so that even if a measure fails the TRC-plus test in 2015, it may be included in a future year if it passes the TRC-plus test in that year.

The payback column presents financial results from a customer perspective. The upfront capital cost of the measure is divided by annual customer cost savings in natural gas, electricity, and water consumption, to obtain the number of years for the measure to pay back its upfront cost. The calculation is repeated for each type of sub-sector in each region, often with varying assumptions for costs and savings. Where this results in a range of payback periods, the range is presented. Where only one number appears, that indicates the payback did not vary significantly.

[66] Measure assumptions are based upon best available data and averages, certain technologies (such as heat pumps measures) require further study.

Exhibit 66 Commercial Measure Potential Savings in 2030



Note:

1) *The measures that are red do not pass the TRC-plus test and the measures that are green pass the TRC-plus test with TRC-plus values greater than 1 for residential (excluding low-income) and greater than 0.7 for low-income residential. The "Other" category is a sum of the measures with potential savings of 15 million cubic metres or less. The category includes twelve measures that pass the TRC-plus test (ENERGY STAR® Clothes Washers, ENERGY STAR® Fryers, ENERGY STAR® Steam Cookers, Heat Reflector Panels, Infrared Heaters, High Efficiency Underfired Broilers, Super-High Efficiency Furnaces, Refrigeration Waste Heat Recovery, ENERGY STAR® Convection Ovens, Keep Doors Closed, Pre-Rinse Spray Nozzles, and ENERGY STAR® Griddles).*

Exhibit 67 Measure Details – Commercial

#	Commercial Measure Name	TRC-Plus	Payback
1	Adaptive Thermostats	0.8 to 4.5	3.0 to life
2	Advanced BAS/Controllers	0.3 to 1.7	7.9 to life
3	Air Curtains	2.7 to 12.3	1.3 to 5.2
4	Boilers - Advanced Controls (Steam Systems)	0.1	Exceeds measure life
5	Boilers - Blowdown Heat Recovery	0.2	Exceeds measure life
6	Boilers - Combustion Air Preheat	0.2	Exceeds measure life
7	Boilers - Feedwater Economizers	0.2	Exceeds measure life
8	Boilers - High Efficiency Burners	0.8	Exceeds measure life
9	Building Recommissioning (Enhanced)	2.2 to 3.7	1.6 to 2.1
10	Building Recommissioning (Standard)	2.2 to 3.7	1.6 to 2.1
11	CEE Tier 2 Clothes Washers	0.5	2.3
12	Commercial Ozone Laundry Treatment	18.4 to 87.3	0.1 to 0.4
13	Condensing Boilers	0.7 to 3.9	4.5 to life
14	Condensing Make-Up Air Units	3.8 to 7.6	1.6 to 2.8
15	Condensing Storage Water Heaters	0.4 to 0.9	13.7 to life
16	Condensing Tankless Water Heaters	0.5 to 1.5	10.0 to life
17	Condensing Unit Heaters	2.0	10.5
18	Demand Control Kitchen Ventilation	3.6	1.9
19	Demand Control Ventilation	1.7 to 5.9	1.6 to 5.8
20	Demand Control Ventilation (Enhanced)	4.2 to 5.1	2.2 to 2.3
21	Destratification Fans	0.8	Exceeds measure life
22	Drain Water Heat Recovery (DWHR)	4.2 to 7.2	2.6 to 4.4
23	Electric Air-Source Cold Climate Heat Pumps*	0.7	Exceeds measure life
24	Electric Ground-Source Heat Pumps*	0.1	Exceeds measure life
25	Energy Recovery Ventilation	0.8 to 2.5	9.0 to life
26	Energy Recovery Ventilation (Enhanced)	1.3 to 2.5	5.4 to 10.6
27	ENERGY STAR Clothes Washers	1.3	1.4
28	ENERGY STAR Convection Ovens	2.0	4.8
29	ENERGY STAR Dishwashers	3.0	1.3
30	ENERGY STAR Fryers	1.5	6.8
31	ENERGY STAR Griddles	14.7	0.9
32	ENERGY STAR Steam Cookers	17.8	0.4
33	Faucet Aerators	7.3	0.0
34	Gas Fired Heat Pumps*	0.2	Exceeds measure life
35	Gas Fired Rooftop Units (Two-Stage)	1.9	7.0
36	Green Roofs	0.0	Exceeds measure life
37	Heat Recovery Ventilation	0.6 to 1.8	Exceeds measure life
38	Heat Reflector Panels	2.2	7.1
39	High Efficiency Boilers	0.3 to 9.6	1.8 to life
40	High Efficiency Underfired Broilers	3.7	2.7
41	High-Performance Glazing	0.1 to 9.3	2.4 to life
42	Indirect Water Heaters	0.2	Exceeds measure life

Note: *Heat pump measures marked with an asterisk (*) indicate that these measures require further study as there are no currently recognized methodologies that assess site versus source energy use from a combined DSM and CDM perspective.*

5.2 Base Year Natural Gas Energy Use

5.2.1 Commercial Sector Segmentation

The Commercial sector is segmented into the following sub-sectors

- Large office
- Medium office*
- Large non-food retail
- Medium non-food retail*
- Food retail
- Large hotel
- Medium hotel*
- Hospital
- Nursing home
- School
- University/college
- Restaurant
- Warehouse
- Apartment
- Low-income apartment
- Other

* All medium sub-sectors include small facilities of that type as well

Where applicable, a “large” sub-sector is defined as having an annual natural gas consumption of greater than 50,000 cubic metres per customer in Union Gas’ service territory and greater than 75,000 cubic metres per customer in Enbridge Gas Distribution’s territory. This split is informed by the methodology used by the utilities to segment natural gas use by sub-sector.[67]

The following table provides a description of the sub-sectors as they apply to this study.

Sub-sector	Definition	Examples of Building Types
Large office	Buildings used for office or public administration	Municipal office, government office building, private office buildings
Medium office	Buildings used for office or public administration	Municipal office, government office building, private office buildings
Large non-food retail	Retail store which primarily sells non-food items	“Big box” store, strip mall, enclosed mall unit
Medium non-food retail	Retail store which primarily sells non-food items	Convenience store, independent retailer
Food retail	Retail store that primarily sells food items and has a significant refrigeration load	Supermarket
Large hotel	Large accommodations with common areas, food preparation, and amenities	Hotel
Medium hotel	Small accommodations with very few amenities	Motel, bed and breakfast

[67] For future combined conservation potential studies, it would be beneficial if the utilities harmonized their approach to segmenting gas use data.

Sub-sector	Definition	Examples of Building Types
Hospital	Hospital or other large, intensive healthcare building	
Nursing home	Buildings used for providing multiple accommodations for long-term care residents	Long-term care facility, retirement home, nursing home
School	Buildings whose primary function is education. Typically characterized by seasonably variable occupancy.	Elementary or secondary school
University/college	Buildings that make up a campus related to post-secondary education	University campus
Warehouse	Typically metal-clad building with high ceilings and predominantly high-bay lighting	
Restaurant	Full service or quick service restaurant	Family restaurant, franchise restaurant, diner
Apartment	Multi-family residential buildings	
Apartment (low-income)	Low-income multi-family residential buildings	
Other building	Commercial or institutional buildings which do not fit into one of the above categories	Arena, community center, service garage, religious building, theatre, prison

5.2.2 End Uses

The Commercial sector includes the following end uses:

- Space heating: Boilers, rooftop units, furnaces
- Service water heating: DHW boilers, storage tank heaters
- CHP: Combined heat and power
- Food service: Food preparation equipment, including ranges, broilers, ovens, etc.
- Other: Pool heating, fireplaces, absorption cooling, sterilizing, etc.

5.2.3 End Use Saturation and Fuel Share Data

Rather than using saturation values, all end uses are considered to be present in each sub-sector, and the prevalence of the end use is modelled through the EUI. For example, restaurants have a larger food service EUI than offices in order to reflect that more floor area is occupied by food service equipment in a restaurant, and there may also be more food service equipment.

The fuel share for each sub-sector and end use is informed by a variety of sources, including Commercial End Use Surveys, ICF's experience, including our team's extensive energy audit experience, and the seasonal variation of the utilities' gas consumption data.

5.2.4 Detailed Building and Equipment Specifications

The EUIs were derived from commercial prototype building models, where available, or by ICF. The prototype building models were developed by the U.S. National Renewable Energy Laboratory (NREL), in conjunction with the U.S. Department of Energy (DOE).[68] These EnergyPlus models were calibrated using a variety of sources, including ICF's experience, detailed models that ICF has developed for prior studies, our extensive energy audit experience, and gas consumption data from the utilities. Specific sources include Union Gas' 2013 Market Penetration of Natural Gas Appliances report and ICF's Commercial Sector Energy End use Models (CSEEM) for buildings in Ontario. The model outputs are all gas EUIs for space heating, service water heating, food service, and other.

Energy use for the two main end uses, space heating and service water heating, were further refined using estimates for the penetration of major equipment types. For example, the penetration of space heating equipment is allocated between standard boilers, near condensing boilers, condensing boilers, rooftop units, and furnaces.

Natural gas use for combined heat and power (CHP) plants was estimated using data from the Canadian Industrial Energy End use Data and Analysis Centre (CIEEDAC). The database includes information on CHP plants that are active and under construction in Ontario, categorized by North American Industry Classification System (NAICS) code, which allows for categorization according to the sub-sectors previously defined. The natural gas use for power generation and hot water or steam production were calculated using available data or estimates for heat to power ratio, plant efficiency, and capacity factor. The service water heating EUIs for each region, and sub-sector were then modified as appropriate based on the amount of CHP present in each sub-sector so that the appropriate portion was allocated to the CHP end use. Natural gas use by the CHP plants for power generation remains in the "Other" end use. Without the adjustment described previously, all natural gas use for CHP would have been allocated to the "Other" category.

5.2.5 Floor Area Calculations

The estimated floor area for each sub-sector was estimated by dividing the natural gas sales data by the whole building natural gas EUI. The general equation for each sub-sector is as follows:

$$Floor\ Area\ [m^2] = \frac{Consumption\ [MJ]}{(EUI_{SH})(FS_{SH}) + (EUI_{SWH})(FS_{SWH}) + (EUI_{FS})(FS_{FS}) + (EUI_{CHP})(FS_{CHP}) + (EUI_{Other})(FS_{Other})}$$

Where, EUI is the energy use intensity in MJ/m²/yr. for the respective end uses

FS is the percent natural gas fuel share for the end use

SH is the space heating end use

SWH is the service water heating end use

CHP is the combined heat and power end use

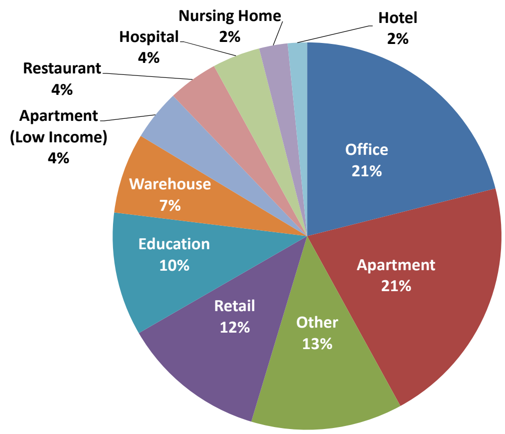
[68] "Commercial Reference Buildings". *Department of Energy.* Available online at: http://energy.gov/eere/buildings/commercial-reference-buildings

5.2.6 Base Case Estimates

Exhibit 67 through Exhibit 70 present the estimated base year consumption of natural gas, broken out by sub-sector, end use, and region, respectively. The following observations can be made:

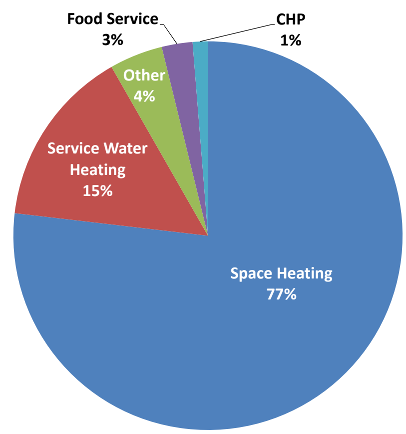
Offices and apartments account for the largest share of natural gas use, each accounting for 21% of the total natural gas use. Other buildings (13%) and retail facilities (12%) also account for a significant portion of the commercial natural gas consumption in the base year. The education sub-sector, which is comprised of schools, universities, and colleges makes up approximately 10% of the overall natural gas use. Warehouses account for 7% of the total natural gas use, with the remaining sub-sectors accounting for less than 5% of the total consumption.

Exhibit 68 Commercial Sector Distribution of Natural Gas Consumption by Sub-sector in the Base Year (2014)



Space heating is the largest end use, accounting for about 77% of commercial sector natural gas use followed by Service Water Heating (15%), Other (4%), Food Service (3%) and CHP (1%).

Exhibit 69 Commercial Sector Distribution of Natural Gas Consumption by End Use in the Base Year (2014)



The Enbridge Gas Distribution service territory accounts for 60% of commercial natural gas consumption, with 52% of the overall consumption being in Enbridge Gas Distribution's GTA region, with the most significant portion of apartment buildings and offices, and 8% in Enbridge Gas Distribution's Eastern service region. The other 40% of natural gas consumption in the Union Gas service territory is comprised of 32% of natural gas consumption in Union Gas' Southern region and 8% in Union Gas' Northern region.

Exhibit 70 Commercial Sector Distribution of Natural Gas Consumption by Region in the Base Year (2014)

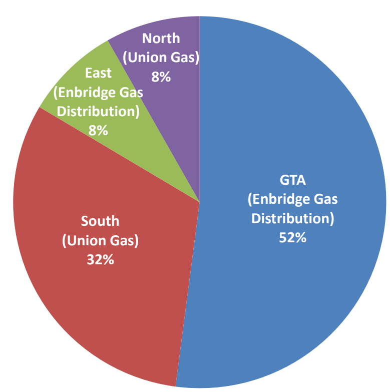


Exhibit 71 Table of Commercial Base Year (2014) Natural Gas Consumption by Sub-sector and Region

Sub-sector	Base Case Consumption, 2014 (1000 m³/yr.)						
	Enbridge Gas Distribution			Union Gas			Grand Total
	GTA	East	Total	North	South	Total	
Large Office	551,567	159,097	710,663	43,014	202,135	245,149	955,812
Medium Office	261,851	46,987	308,837	57,412	170,076	227,487	536,324
Large Non-food Retail	162,283	20,851	183,133	14,342	86,340	100,681	283,815
Medium Non-food Retail	151,930	24,933	176,863	45,911	154,396	200,306	377,170
Food Retail	98,429	16,008	114,437	21,043	55,681	76,723	191,160
Large Hotel	54,287	5,793	60,080	10,070	13,274	23,344	83,424
Medium Hotel	12,396	2,405	14,802	6,245	9,106	15,351	30,153
Hospital	78,576	21,748	100,324	36,500	144,691	181,192	281,515
Nursing Home	65,368	13,342	78,709	26,391	62,524	88,915	167,625
School	203,474	35,134	238,608	31,113	128,964	160,077	398,685
University/College	122,575	17,521	140,096	32,511	158,405	190,915	331,011
Restaurant	109,197	20,563	129,760	34,031	131,920	165,950	295,710
Warehouse/Wholesale	224,542	12,515	237,058	41,036	197,591	238,627	475,684
Apartment	1,162,691	123,012	1,285,702	21,085	180,597	201,682	1,487,384
Apartment (Low Income)	189,275	20,025	209,300	9,473	81,138	90,611	299,911
Other	243,227	44,033	287,261	152,063	454,453	606,516	893,777
Total Low-Income Commercial	189,275	20,025	209,300	9,473	81,138	90,611	299,911
Total Non-Low-Income Commercial	3,502,393	563,941	4,066,334	572,766	2,150,150	2,722,915	6,789,249
Grand Total	3,691,668	583,966	4,275,634	582,239	2,231,287	2,813,526	7,089,160

5.3 Reference Case

5.3.1 Natural replacement

To model the changes to the existing building stock, EUIs for each sub-sector and end use were adjusted to account for natural changes in gas use caused by both changes to demand (e.g. reduced space heating demand due to improved insulation) and equipment efficiency (e.g. improved boiler efficiency). Changes to electrical equipment loads were accounted for in instances where they will have an impact on natural gas use through interactive effects (e.g. interior lighting loads are expected to decline, plug loads are expected to increase).

EUIs for new buildings were determined by adjusting the calibrated Base Case EnergyPlus models so that they reflect new construction practices and realistic actual operating conditions. Changes to fuel share were also modelled through new construction as this has a greater impact than fuel switching in existing buildings. Growth in floor space was modelled by calibrating the overall sector growth in natural gas use to the utilities' forecasts, assuming that new floor space is either new construction or a significant renovation, which would be built to new construction practices and have a comparable EUI. Changes to EUIs of the existing building stock were also taken into account prior to accounting for new construction. Floor area growth between sub-sectors was modelled by taking into account the relative growth rates between sub-sectors, (e.g. hospital area may expand more slowly than apartment floor area) using data from the IESO's 2013 Long Term Energy Plan[69].

5.3.2 Codes and Standards

Changes to codes and standards were modelled through their impact on EUIs by affecting both energy demand (e.g. improved insulation) and equipment efficiency (e.g. hot water boilers for new buildings must have an efficiency greater than 90% from January 1, 2017).

Growth in CHP was modelled using studies of the Ontario market developed by ICF for other clients.

[69] IESO, Long-Term Energy Plan (LTEP) 2013, Module 1: Demand Forecast, Jan. 2014, available online at: http://www.powerauthority.on.ca/power-planning/long-term-energy-plan-2013

5.3.3 Reference Case Forecast of Natural Gas Use

Exhibit 72 through Exhibit 77 show the estimated reference case consumption of natural gas, broken out by sub-sector and region, and then by end use.

As shown in Exhibit 72 and Exhibit 73, the commercial consumption of natural gas in Ontario is expected to rise from approximately 7,089 million cubic metres in 2014 to approximately 8,561 million cubic metres in 2030, in the absence of new conservation programs, which represents an increase of approximately 21%.

Offices and apartments continue to account for the largest share of natural gas use within the sub-sectors. Offices and apartments each remain at 21% of natural gas consumption and retail remains at 12% of natural gas consumption over the study period from 2014 to 2030.

As shown in Exhibit 74 and Exhibit 75, the Enbridge Gas Distribution service territory accounts for 61% (5,248 million cubic metres) of commercial natural gas consumption by the end of the study period (4,532 million cubic metres or 53% in the GTA and 716 million cubic metres or 8% in the eastern region). The Union Gas service territory accounts for the other 3,313 million cubic metres or 39% of commercial natural gas consumption (2,633 million cubic metres or 31% in the southern region and 680 million cubic metres or 8% in the northern region).

A shown in Exhibit 76 and Exhibit 77, space heating remains the largest end use by 2030, at 6,505 million cubic metres, or 76% of commercial sector natural gas use followed by service water heating (15%), other (4%), food service (3%) and CHP (2%).

Exhibit 72 Graph of Commercial Reference Case Natural Gas Consumption by Sub-sector and Year

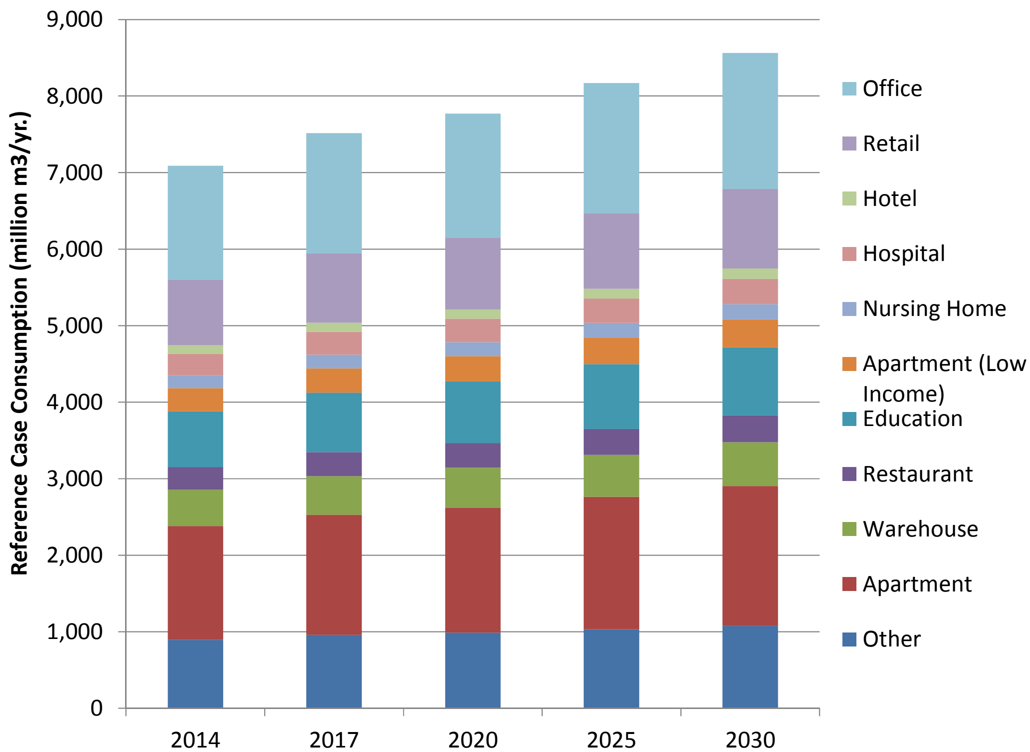


Exhibit 73 Table of Commercial Reference Case Natural Gas Consumption by Sub-sector and Year

Sub-Sector	Consumption (million m³/yr.)				
	2014	2017	2020	2025	2030
Office	1,492	1,571	1,620	1,699	1,774
Retail	852	906	938	988	1,041
Hotel	114	119	123	129	134
Hospital	282	298	307	319	330
Nursing Home	168	178	183	192	199
Education	730	777	805	846	888
Restaurant	296	314	324	338	353
Warehouse	476	505	522	548	573
Apartment	1,487	1,571	1,631	1,731	1,827
Apartment (Low Income)	300	317	329	347	365
Other	894	958	989	1,033	1,076
Total Low-Income Commercial	300	317	329	347	365
Total Non-Low-Income Commercial	6,789	7,197	7,442	7,823	8,196
Total	7,089	7,515	7,771	8,170	8,561

Exhibit 74 Graph of Commercial Reference Case Natural Gas Consumption by Region and Year

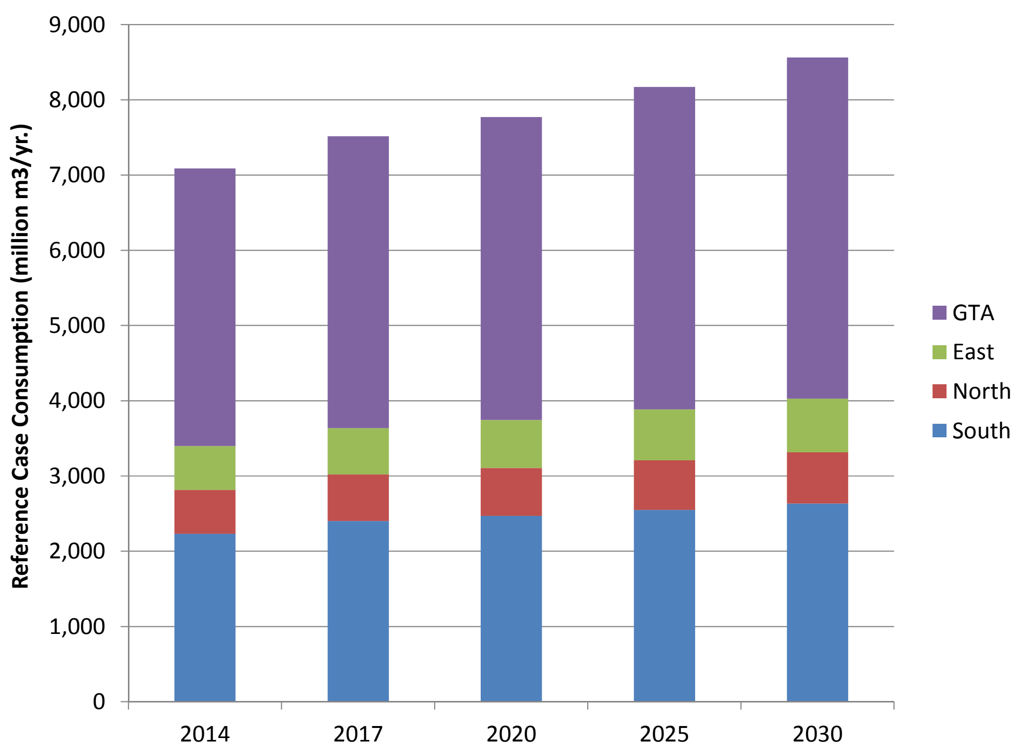


Exhibit 75 Table of Commercial Reference Case Natural Gas Consumption by Region and Year

Utility	Region	Consumption (million m³/yr.)				
		2014	2017	2020	2025	2030
Enbridge Gas Distribution	GTA	3,692	3,879	4,027	4,286	4,532
	East	584	614	637	678	716
Union Gas	North	582	622	637	658	680
	South	2,231	2,401	2,470	2,549	2,633
Total		7,089	7,515	7,771	8,170	8,561

Exhibit 76 Graph of Commercial Reference Case Natural Gas Consumption by End Use and Year

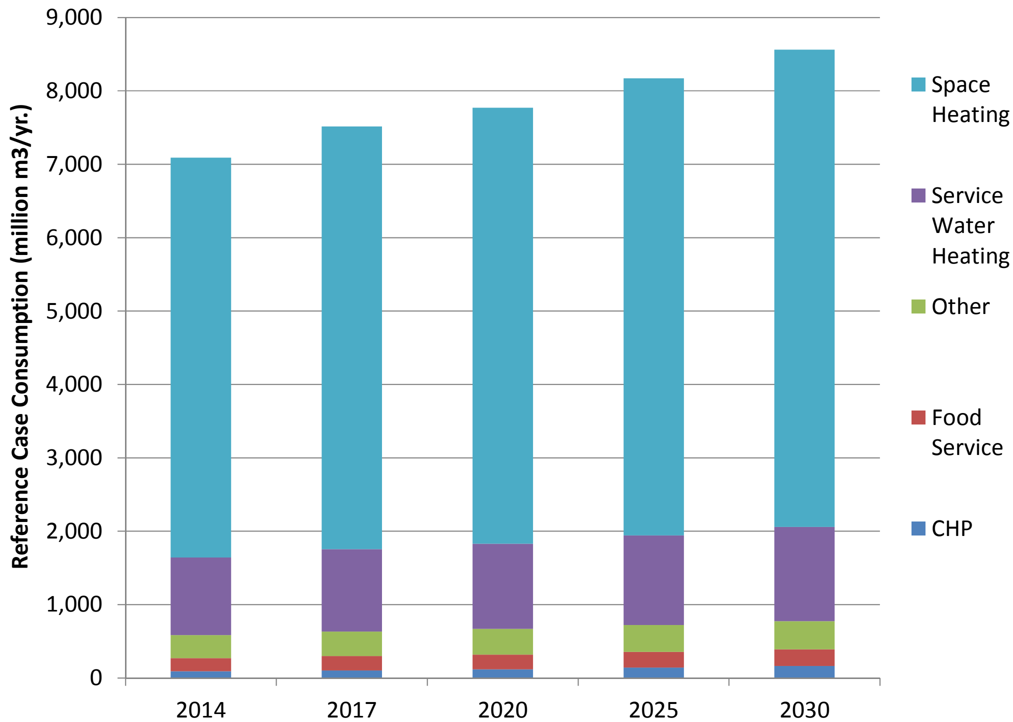


Exhibit 77 Table of Commercial Reference Case Natural Gas Consumption by End Use and Year

End Use	Consumption (million m^3/yr.)				
	2014	2017	2020	2025	2030
Space Heating	5,448	5,759	5,943	6,227	6,505
Service Water Heating	1,056	1,122	1,161	1,222	1,281
Other	314	335	347	366	385
Food Service	182	194	202	213	225
CHP	90	104	118	141	165
Total	7,089	7,515	7,771	8,170	8,561

5.4 Technical Potential

This section presents estimates of commercial technical potential based on the methodology discussed in section 2.6. Exhibit 78 through Exhibit 85 show the technical potential savings for the commercial sector.

As shown in Exhibit 78 and Exhibit 79, adoption of all technically-feasible measures could potentially reduce commercial natural gas consumption by 35% by 2020, or from 7,771 million cubic metres to 5,075 million cubic metres in 2020, and by 47% by 2030, or from 8,561 million cubic metres to 4,511 million cubic metres by 2030.[70]

Exhibit 78 Graph of Commercial Reference Case versus Technical Potential Consumption

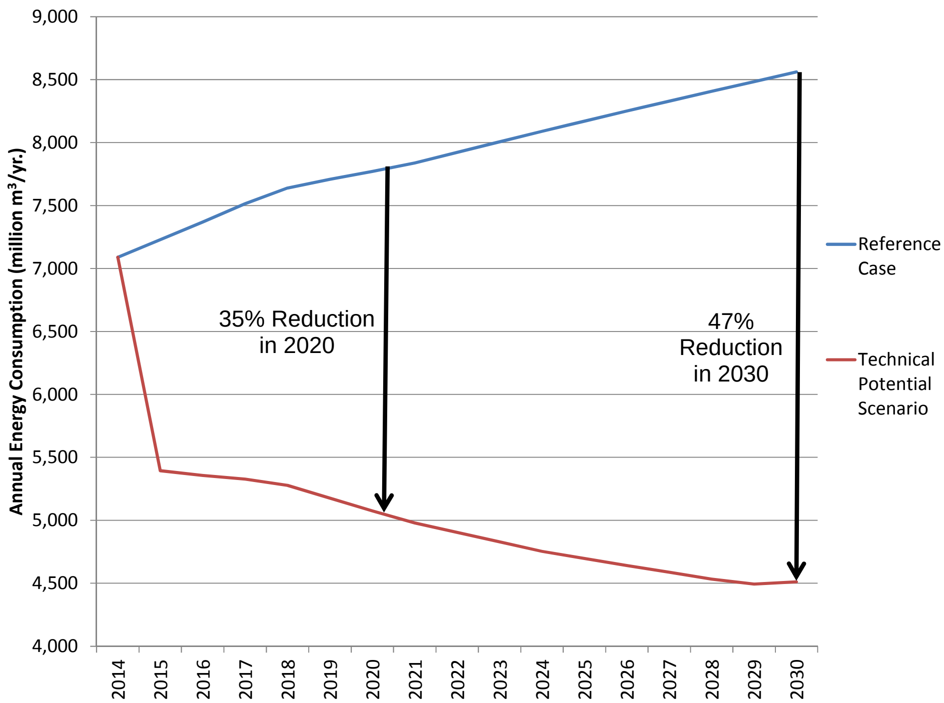


Exhibit 79 Table of Commercial Reference Case versus Technical Potential Consumption

Milestone Year	Consumption (million m^3/yr.)	
	Reference Case	Technical Potential
2014	7,089	7,089
2015	7,229	5,394
2016	7,369	5,356
2017	7,515	5,326
2018	7,639	5,277
2019	7,708	5,177
2020	7,771	5,075
2025	8,170	4,697
2030	8,561	4,511

[70] This high savings potential is largely due to the inclusion of heat pump measures in the technical potential. These measures have a large impact on the space heating energy consumption of commercial buildings. However, as noted in Section 5.1, these measures do not pass the TRC-plus test. As such, they are not included in the savings potential for subsequent scenarios.

A shown in Exhibit 80 and Exhibit 81, the technical savings potential for offices increased from 519 million cubic metres in 2020 to 799 million cubic metres in 2030 while the share of total technical potential savings attributed to offices increased slightly from 19% in 2020 to 20% in 2030. The technical savings potential for the retail sector increased from 452 million cubic metres in 2020 to 709 million cubic metres in 2030 while the share of total technical potential savings attributed to retail increased slightly from 17% in 2020 to 18% in 2030. The technical savings potential for apartments increased from 430 million cubic metres in 2020 to 658 million cubic metres in 2030 while the share of total technical potential savings attributed to apartments remained unchanged at 16%.

The other category accounted for 12% (484 million cubic metres) of the 2030 technical potential savings, with another 10% (409 million cubic metres) savings in warehouses, 10% (389 million cubic metres) savings in education, and 5% (185 million cubic metres) of 2030 savings in restaurants. The remaining sub-sectors account for less than 5% of the 2030 technical potential savings.

Space heating accounted for 81% (2,180 million cubic metres) of commercial technical savings potential by 2020, with service water heating accounting for approximately 18% (480 million cubic metres). The remaining end uses each account for 1% or less of the 2020 technical savings potential. By 2030, the space heating end use accounts for 84% (3,396 million cubic metres) of the commercial technical savings potential, service water heating accounts for 15% (595 million cubic metres) and the remaining end uses still each account for 1% or less of the technical savings potential.

As shown in Exhibit 82 and Exhibit 83 the technical potential savings in the Enbridge Gas Distribution’s service territory increased from 1,578 million cubic metres in 2020 to 2,404 million cubic metres in 2030 while the technical potential savings in the Union Gas’ service territory increased from 1,117 million cubic metres in 2020 to 1,646 million cubic metres in 2030. Buildings in Enbridge Gas Distribution’s service territory accounted for approximately 59% of the commercial technical savings potential by 2030, with buildings in Union Gas’ service territory accounting for the remaining 41%.

As shown in Exhibit 84 and Exhibit 85, the technical potential savings of existing buildings increased from 2,649 million cubic metres in 2020 to 3,782 million cubic metres in 2030 while the technical potential savings of new buildings increased from 47 million cubic metres in 2020 to 269 million cubic metres in 2030. Existing buildings accounted for approximately 98% of the commercial technical savings potential in 2020 which decreased to 93% of the commercial technical savings potential in 2030.

Exhibit 80 Graph of Commercial Technical Potential Savings by Use, Year, and Sub-Sector

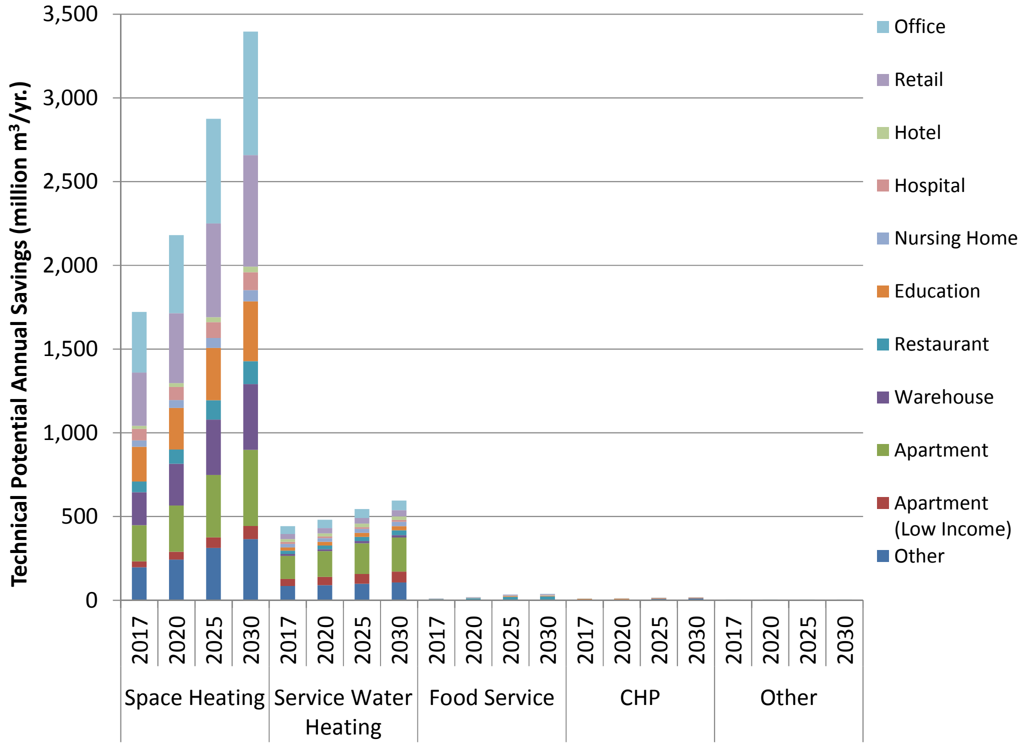


Exhibit 81 Table of Commercial Technical Potential Savings by Use, Year, and Sub-Sector

End Use	Milestone Year	Savings (million m³/yr.)											
		Office	Retail	Hotel	Hospital	Nursing Home	Education	Restaurant	Warehouse	Apartment	Apartment (Low Income)	Other	Total
Space Heating	2017	362	319	19	68	38	208	65	196	216	35	197	1,722
	2020	467	417	23	78	47	249	85	249	276	47	243	2,180
	2025	624	561	29	95	59	313	115	331	372	64	312	2,875
	2030	738	665	34	107	67	357	136	394	454	79	365	3,396
Service Water Heating	2017	47	30	17	11	20	21	19	12	137	43	85	442
	2020	49	31	18	11	22	22	21	13	154	48	90	480
	2025	53	34	20	11	25	24	24	14	183	58	99	545
	2030	57	37	22	11	27	25	27	15	204	64	107	595
Food Service	2017	0	2	0	0	0	1	5	-	-	-	0	9
	2020	1	3	0	0	1	2	11	-	-	-	1	19
	2025	1	6	1	1	2	3	19	-	-	-	1	34
	2030	1	6	1	1	2	4	21	-	-	-	2	37
CHP	2017	0	-	0	3	-	3	-	-	0	-	4	10
	2020	0	-	0	3	-	3	-	-	0	-	6	12
	2025	0	-	0	3	-	3	-	-	0	-	8	14
	2030	0	-	0	3	-	3	-	-	0	-	10	17
Other	2017	2	0	0	0	0	0	0	0	0	0	1	5
	2020	2	0	0	0	0	0	0	0	0	0	1	5
	2025	2	0	0	0	0	0	0	0	0	0	1	5
	2030	2	0	0	0	0	0	0	0	0	0	1	5
Grand Total	2017	412	350	36	82	59	232	90	209	353	78	287	2,189
	2020	519	452	42	93	70	276	117	262	430	95	340	2,696
	2025	681	602	50	110	85	343	159	345	555	122	422	3,473
	2030	799	709	56	122	96	389	185	409	658	143	484	4,051

Exhibit 82 Graph of Commercial Technical Potential Savings by Use, Year, and Utility

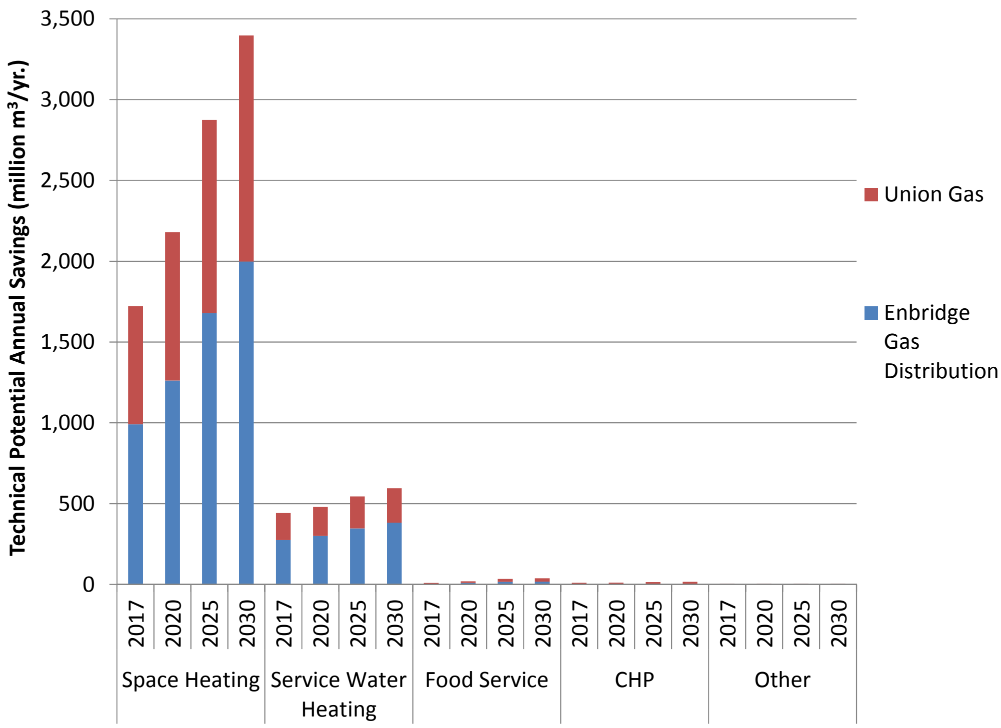


Exhibit 83 Table of Commercial Technical Potential Savings by Use, Year, and Utility

End Use	Milestone Year	Savings (million m³/yr.)		
		Enbridge Gas Distribution	Union Gas	Total
Space Heating	2017	990	731	1,722
	2020	1,262	918	2,180
	2025	1,678	1,197	2,875
	2030	1,998	1,399	3,396
Service Water Heating	2017	274	168	442
	2020	301	180	480
	2025	346	199	545
	2030	382	213	595
Food Service	2017	4	5	9
	2020	9	10	19
	2025	16	18	34
	2030	18	20	37
CHP	2017	4	6	10
	2020	4	8	12
	2025	4	10	14
	2030	4	12	17
Other	2017	3	2	5
	2020	3	2	5
	2025	3	2	5
	2030	3	2	5
Grand Total	**2017**	**1,276**	**913**	**2,189**
	2020	**1,578**	**1,117**	**2,696**
	2025	**2,048**	**1,425**	**3,473**
	2030	**2,404**	**1,646**	**4,051**

Exhibit 84 Graph of Commercial Technical Potential Savings by Use, Year, and Vintage

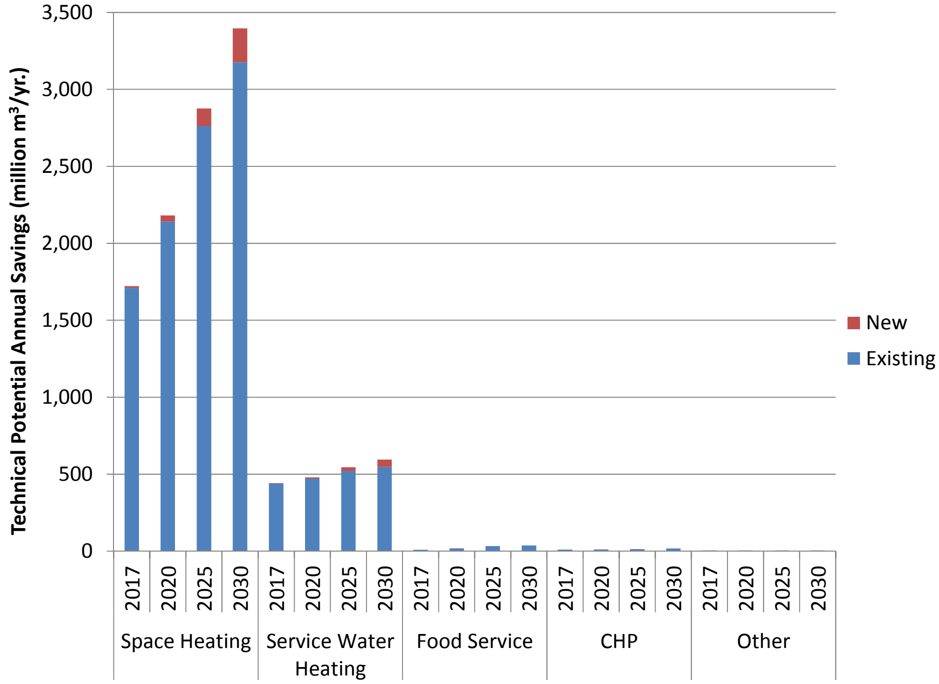


Exhibit 85 Table of Commercial Technical Potential Savings by Use, Year, and Vintage

End Use	Milestone Year	Savings (million m^3/yr.)		
		Existing	New	Total
Space Heating	2017	1,710	12	1,722
	2020	2,142	39	2,180
	2025	2,762	113	2,875
	2030	3,176	221	3,396
Service Water Heating	2017	440	3	442
	2020	472	8	480
	2025	521	24	545
	2030	547	48	595
Food Service	2017	9	-	9
	2020	19	-	19
	2025	34	-	34
	2030	37	-	37
CHP	2017	10	-	10
	2020	12	-	12
	2025	14	-	14
	2030	17	-	17
Other	2017	5	-	5
	2020	5	-	5
	2025	5	-	5
	2030	5	-	5
Grand Total	2017	2,174	15	2,189
	2020	2,649	47	2,696
	2025	3,336	137	3,473
	2030	3,782	269	4,051

5.5 Economic Potential

This section presents estimates of commercial economic potential based on the methodology discussed in section 2.7. Exhibit 86 through Exhibit 93 show the economic potential savings for the commercial sector.

As shown in Exhibit 86 and Exhibit 87, adoption of all economically-feasible measures could potentially reduce commercial natural gas consumption by 25% by 2020, or from 7,771 million cubic metres to 5,835 million cubic metres in 2020, and by 30% by 2030, or from 8,561 million cubic metres to 5,969 million cubic metres by 2030.

Exhibit 86 Graph of Commercial Reference Case, Technical Potential, and Economic Potential Consumption

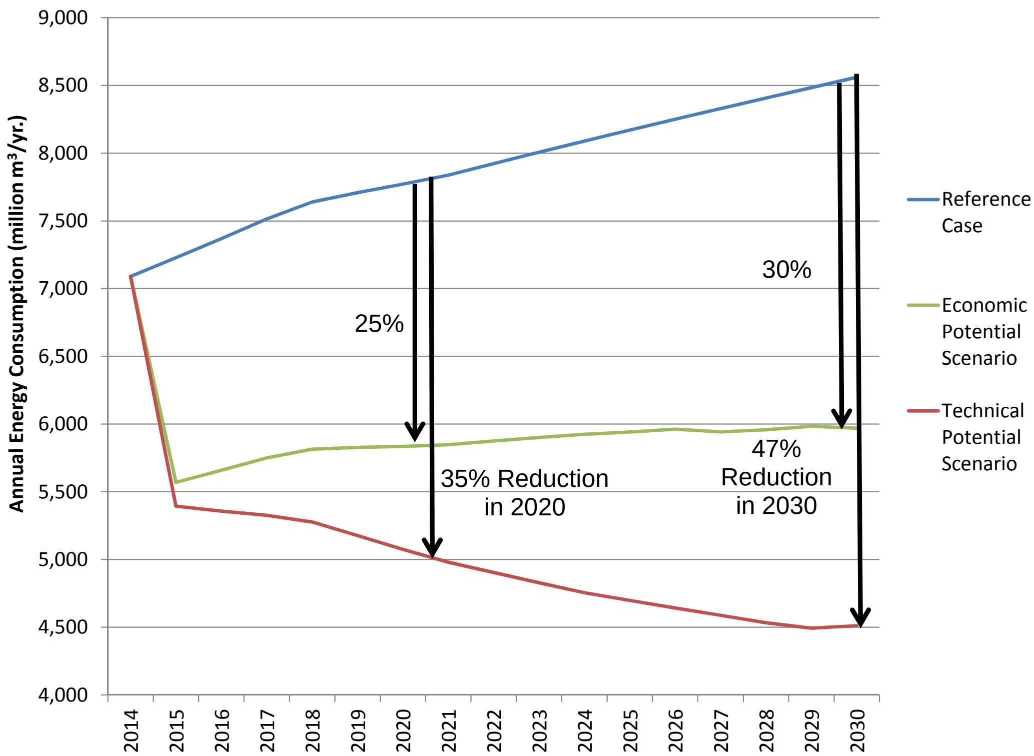


Exhibit 87 Table of Commercial Reference Case, Technical Potential, and Economic Potential Consumption

Milestone Year	Consumption (million m^3/yr.)		
	Reference Case	Technical Potential Scenario	Economic Potential Scenario
2014	7,089	7,089	7,089
2015	7,229	5,394	5,570
2016	7,369	5,356	5,658
2017	7,515	5,326	5,749
2018	7,639	5,277	5,814
2019	7,708	5,177	5,827
2020	7,771	5,075	5,835
2025	8,170	4,697	5,941
2030	8,561	4,511	5,969

As shown in Exhibit 88 and Exhibit 89, the economic savings potential for offices increased from 371 million cubic metres in 2020 to 489 million cubic metres in 2030 while the share of total economic potential savings attributed to offices remained unchanged at 19%. The economic savings potential for apartments increased from 351 million cubic metres in 2020 to 487 million cubic metres in 2030 while the share of total economic potential savings attributed to apartments increased slightly from 18% to 19%. The economic savings potential for the other sector increased from 275 million cubic metres in 2020 to 360 million cubic metres in 2030 while the share of total economic potential savings attributed to the other sub-sector remained stable, at 14%. The economic savings potential for the retail sector increased from 249 million cubic metres in 2020 to 351 million cubic metres in 2030 while the share of total economic potential savings attributed to retail increased from 13% in 2020 to 14% in 2030.

The remainder of the 2030 economic potential savings were found to be 9% (242 million cubic metres) in education, 7% (193 million cubic metres) in warehouses, 5% (125 million cubic metres) in restaurants and less than 5% in each of the remaining sub-sectors.

Space heating accounted for 76% (1,472 million cubic metres) of commercial economic savings potential by 2020, with service water heating accounting for approximately 22% (429 million cubic metres). The remaining end uses each account for 1% or less of the 2020 economic savings potential. By 2030, the space heating end use accounts for 79% (2,057 million cubic metres) of the commercial economic savings potential, service water heating accounts for 18% (476 million cubic metres) and the remaining end uses each account for 1% or less of the economic savings potential.

As shown in Exhibit 90 and Exhibit 91, the economic potential savings in the Enbridge Gas Distribution's service territory increased from 1,140 million cubic metres in 2020 to 1,549 million cubic metres in 2030 while the economic potential savings in the Union Gas' service territory increased from 796 million cubic metres in 2020 to 2,592 million cubic metres in 2030. Buildings in Enbridge Gas Distribution's service territory accounted for approximately 60% of the commercial economic savings potential by 2030, with buildings in Union Gas' service territory accounting for the remaining 40%.

As shown in Exhibit 92 and Exhibit 93, the economic potential savings of existing buildings increased from 1,914 million cubic metres in 2020 to 2,453 million cubic metres in 2030 while the economic potential savings of new buildings increased from 22 million cubic metres in 2020 to 138 million cubic metres in 2030. Existing buildings accounted for 99% of the commercial economic savings potential in 2020 which decreased to 95% of the commercial economic savings potential in 2030.

Exhibit 88 Graph of Commercial Economic Potential Savings by Use, Year, and Sub-Sector

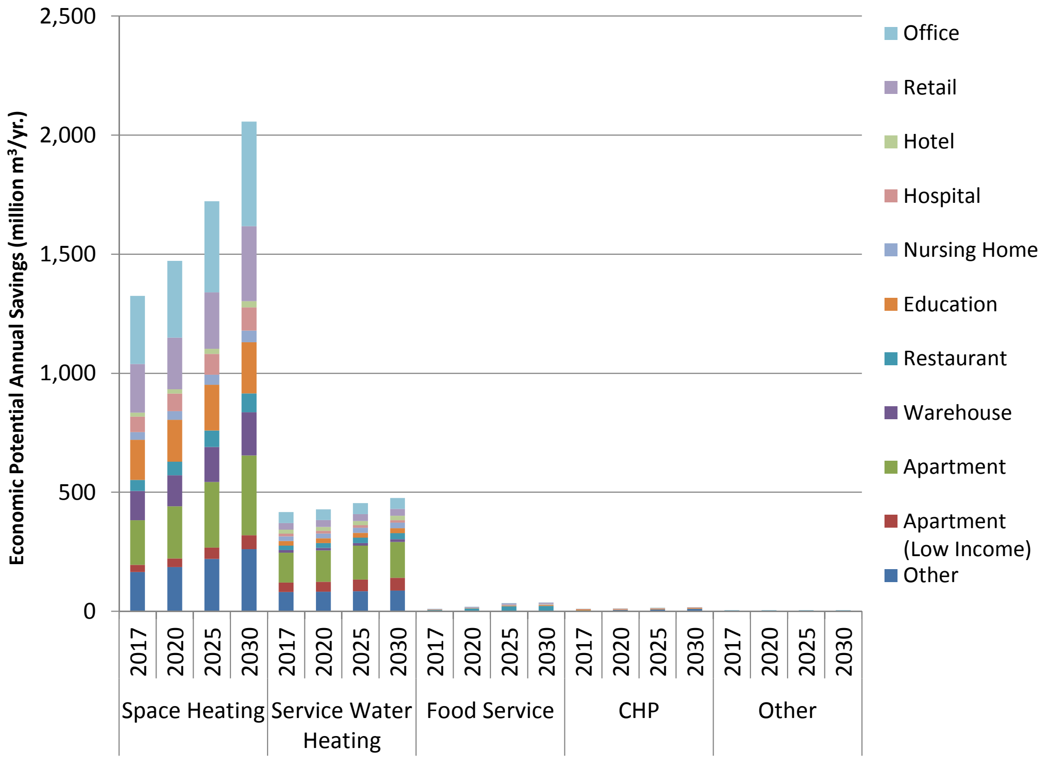


Exhibit 89 Table of Commercial Economic Potential Savings by Use, Year, and Sub-Sector

End Use	Milestone Year	Savings (million m³/yr.)											
		Office	Retail	Hotel	Hospital	Nursing Home	Education	Restaurant	Warehouse	Apartment	Apartment (Low Income)	Other	Total
Space Heating	2017	286	205	16	65	32	168	46	124	187	30	165	1,325
	2020	323	217	18	74	36	176	57	130	219	36	185	1,472
	2025	382	237	22	88	43	191	70	147	276	47	220	1,722
	2030	439	315	25	98	49	215	79	181	336	58	261	2,057
Service Water Heating	2017	45	28	16	11	19	20	19	11	125	40	81	416
	2020	45	29	17	11	20	20	20	11	131	42	82	429
	2025	46	29	18	11	22	20	23	11	142	49	84	454
	2030	46	29	19	10	23	21	25	11	151	53	87	476
Food Service	2017	0	2	0	0	0	1	5	-	-	-	0	9
	2020	1	3	0	0	1	2	11	-	-	-	1	19
	2025	1	6	1	1	2	3	19	-	-	-	1	34
	2030	1	6	1	1	2	4	21	-	-	-	2	37
CHP	2017	0	-	0	3	-	3	-	-	0	-	4	10
	2020	0	-	0	3	-	3	-	-	0	-	6	12
	2025	0	-	0	3	-	3	-	-	0	-	8	14
	2030	0	-	0	3	-	3	-	-	0	-	10	17
Other	2017	2	0	0	0	0	0	0	0	0	0	1	5
	2020	2	0	0	0	0	0	0	0	0	0	1	5
	2025	2	0	0	0	0	0	0	0	0	0	1	5
	2030	2	0	0	0	0	0	0	0	0	0	1	5
Grand Total	2017	335	235	33	80	53	192	70	135	313	70	251	1,766
	2020	371	249	36	88	57	201	88	142	351	79	275	1,936
	2025	432	272	41	102	66	218	112	158	418	96	314	2,229
	2030	489	351	45	112	75	242	125	193	487	112	360	2,592

Exhibit 90 Graph of Commercial Economic Potential Savings by Use, Year, and Utility

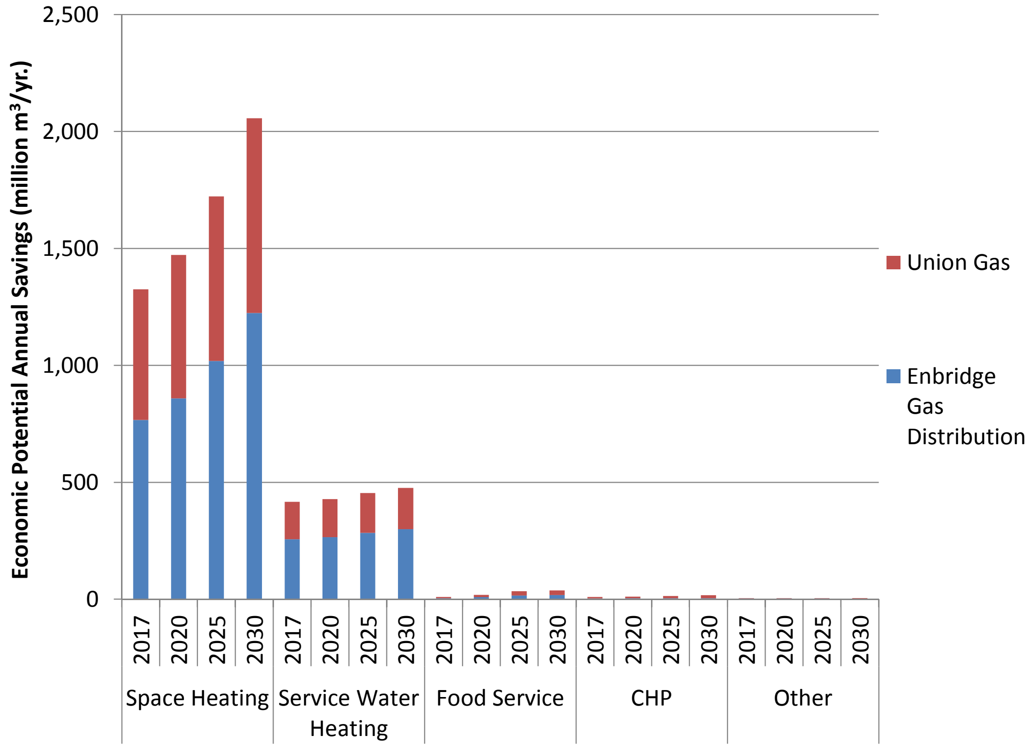


Exhibit 91 Table of Commercial Economic Potential Savings by Use, Year, and Utility

End Use	Milestone Year	Savings (million m^3/yr.)		
		Enbridge Gas Distribution	Union Gas	Total
Space Heating	2017	767	558	1,325
	2020	859	613	1,472
	2025	1,018	704	1,722
	2030	1,224	833	2,057
Service Water Heating	2017	257	160	416
	2020	265	163	429
	2025	284	170	454
	2030	300	176	476
Food Service	2017	4	5	9
	2020	9	10	19
	2025	16	18	34
	2030	18	20	37
CHP	2017	4	6	10
	2020	4	8	12
	2025	4	10	14
	2030	4	12	17
Other	2017	3	2	5
	2020	3	2	5
	2025	3	2	5
	2030	3	2	5
Grand Total	**2017**	**1,034**	**731**	**1,766**
	2020	**1,140**	**796**	**1,936**
	2025	**1,325**	**904**	**2,229**
	2030	**1,549**	**1,043**	**2,592**

Exhibit 92 Graph of Commercial Economic Potential Savings by Use, Year, and Vintage

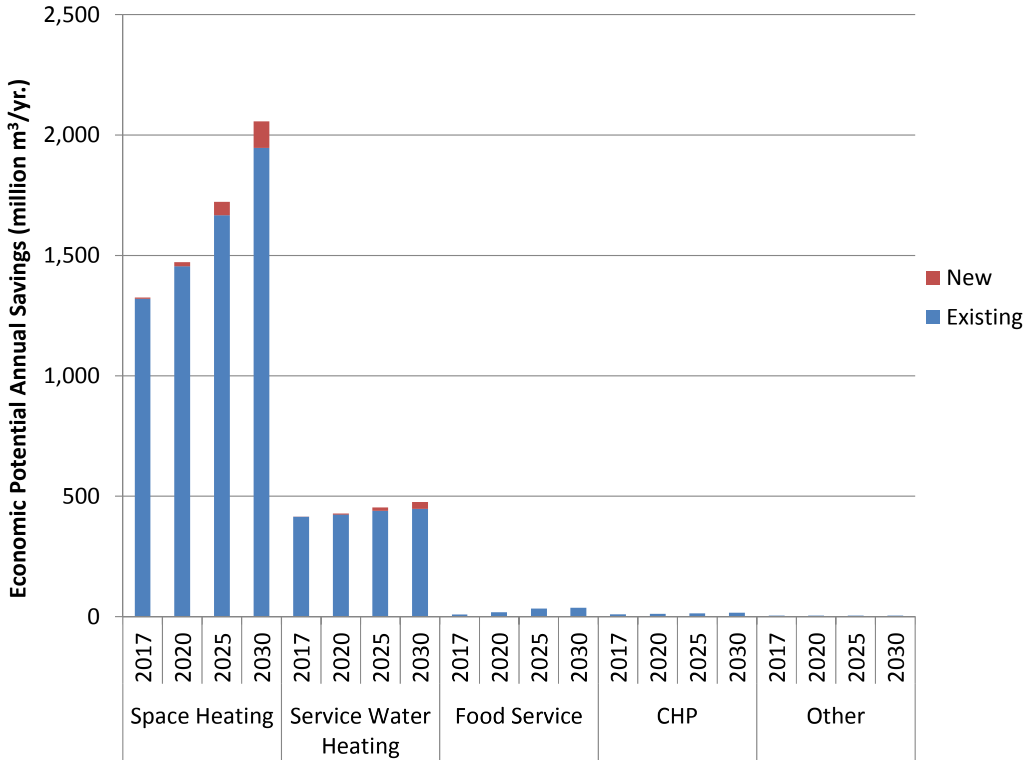


Exhibit 93 Table of Commercial Economic Potential Savings by Use, Year, and Vintage

End Use	Milestone Year	Savings (million m^3/yr.)		
		Existing	New	Total
Space Heating	2017	1,320	5	1,325
	2020	1,455	17	1,472
	2025	1,667	56	1,722
	2030	1,947	110	2,057
Service Water Heating	2017	415	1	416
	2020	424	5	429
	2025	440	14	454
	2030	448	28	476
Food Service	2017	9	-	9
	2020	19	-	19
	2025	34	-	34
	2030	37	-	37
CHP	2017	10	-	10
	2020	12	-	12
	2025	14	-	14
	2030	17	-	17
Other	2017	5	-	5
	2020	5	-	5
	2025	5	-	5
	2030	5	-	5
Grand Total	2017	1,759	7	1,766
	2020	1,914	22	1,936
	2025	2,159	70	2,229
	2030	2,453	138	2,592

5.6 Achievable Potential

This section presents estimates of commercial achievable potential based on the methodology discussed in section 2.8.

5.6.1 Summary of Commercial Sector Interviews

Eight commercial interviews were conducted in order to collect information for the achievable potential scenarios. The following measure categories as primary topics (in each case, other related measures were discussed at the end):

- Condensing Boilers
- Building Recommissioning
- Heat Recovery Ventilation
- Roof Insulation
- Condensing Storage Water Heaters
- New Construction
- ENERGY STAR® Fryers

Interviewees were asked to focus on one target type of building and then later discuss variations.

5.6.2 Program cost assumptions

The level of the incentive that was required was based on the consultations, input from the utilities, and ICF's experience. ICF considered both the fraction of measure cost and its impact on the simple payback for the measure, relative to the payback the customer might require. In the case of the BAU incentives, this information was supplemented by information on the incentive levels used in current Ontario gas utility commercial programs, where such programs included the measure being analyzed. For the BAU cases, the ratio of non-incentive to incentive costs was set at 0.5, based on ICF's professional experience in Ontario's commercial sector. However, a higher ratio was used in cases where measure costs are quite low (e.g. faucet aerators). Aggressive programs with higher incentive costs would generally need a lower ratio. As such, it was assumed that the ratio for aggressive cases was proportionally lower. Where incentives were very low or zero, in order to more accurately account for non-incentive costs, ICF used PAC test ratios to set the program cost, using a ratio of 4.0 for the BAU programs and 3.0 for the aggressive programs. These ratio were selected based on ICF's program experience.

Low-income programs were assumed to have a higher ratio of non-incentive costs to incentive costs due to the increased level of program support that is normally required to deliver this type of program. They were also assumed to have lower PAC test hurdle rates than the other commercial programs, per OEB DSM guidelines.

5.6.3 Program Cost Supply Curves and Achievable Savings

The 2015-2020 supply curves for the commercial sector (excluding low-income) and low-income program achievable scenarios up to the 2020 milestone year are shown in Exhibit 94 and Exhibit 96, respectively.

Presented in Exhibit 95 is a summary of the commercial sector (excluding low-income) achievable potential savings and program costs for each achievable potential scenario in 2020 and in 2030.

Semi-constrained and constrained program spending were $214 million and $157 million, respectively, for the commercial sector (excluding low-income) in 2015-2020. Semi-constrained and constrained program spending were $571 million and $286 million, respectively, for the commercial sector (excluding low-income) in 2020-2030, for total spending up to 2030 of $785 million or 30% of the total spending of the commercial (excluding low-income) unconstrained program. Total savings of natural gas were 11,918 million cubic metres or 48% of the total savings of natural gas in the commercial (excluding low-income) unconstrained program.

In the commercial (excluding low-income) constrained program, the total spending up to 2030 was $442 million or 56% of the total spending of the commercial (excluding low-income) semi-constrained program while the total savings of natural gas was 7,907 million cubic metres or 66% of the total savings of natural gas in the commercial (excluding low-income) semi-constrained program.

For the commercial (excluding low-income) semi-constrained program, the average program spending up to 2020 is about $0.07 per cubic metre of natural gas saved. For the commercial (excluding low-income) constrained program, the average program spending up to 2020 is about $0.06 per cubic metre of natural gas saved.

Exhibit 94 Commercial (excluding low-income) Supply Curve: Program Costs for 2015 to 2020

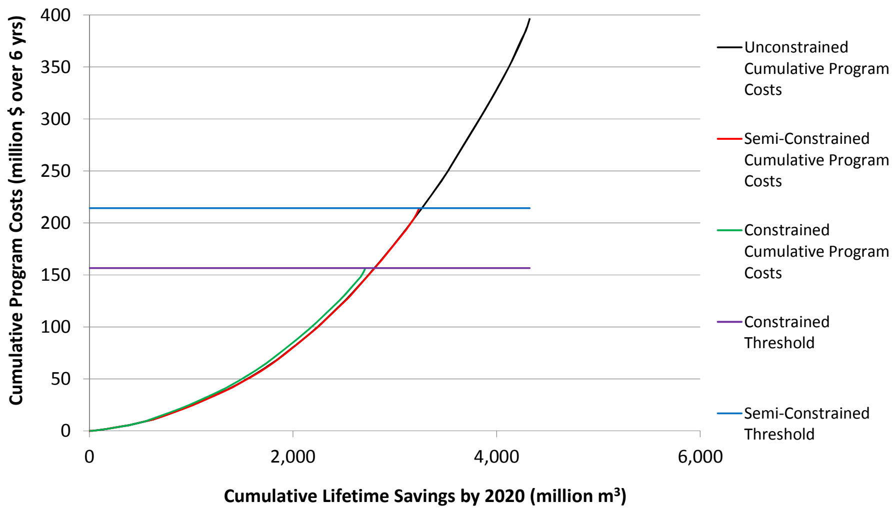


Exhibit 95 Commercial (excluding low-income) Achievable Potential Savings and Program Cost Results[71]

Value	Unconstrained		Semi-Constrained		Constrained	
	Year					
	2020	2030	2020	2030	2020	2030
Annual Savings (million m^3/yr.)	336	1,497	226	731	196	504
Measure Lifecycle Savings (million m^3)	4,324	24,804	3,239	11,918	2,710	7,907
Value of Savings (million $)	673	4,220	503	1,978	419	1,302
Program Spending to Milestone Year (million $)	396*	2,595*	214	785	157	442
Average Annual Program Spending (million $/yr.)	66*	162*	36	49	26	28
Average Program Spending up to Milestone Year ($/$m^3$)	0.09*	0.10*	0.07	0.07	0.06	0.06

**Note: These are not specific program costs but are the total costs for the scenario.*

As shown in Exhibit 96, the program costs to 2020 in the unconstrained scenario for multi-family low-income are lower than the budgets available under both the constrained and semi-constrained scenarios. The program costs to 2030 are lower than the budgets available under the semi-constrained scenario, therefore the existing low-income commercial program budget would only ever be fully spent by 2030 under the aggressive version of the program. The multi-family low-income budget makes up a substantially larger proportion of the commercial sector budget compared to the proportion of natural gas consumed by this sub-sector multi-family, making it challenging to find sufficient natural gas savings in the multi-family sub-sector.

[71] See footnote 64 for details on the values in this table.

Presented in Exhibit 97 is a summary of the low-income commercial sector achievable potential savings and program costs for each achievable potential scenario in 2020 and in 2030.

As was previously noted, the estimated multi-family low-income unconstrained achievable program spending for 2020 of $27 million is below the budget levels available in the semi-constrained and constrained scenarios, therefore multi-family low-income program spending in 2020 remains unchanged across the three achievable scenarios. Constrained and semi-constrained program spending were both $27 million for low-income in 2015-2020. For multi-family low-income in 2020-2030, the constrained and semi-constrained program spending were $104 million and $144 million, respectively.

In the low-income commercial constrained program, the total spending up to 2030 was $131 million or 76% of the total spending of the low-income commercial semi-constrained program while the total savings of natural gas was 872 million cubic metres or 87% of the total savings of natural gas in the commercial (excluding low-income) semi-constrained program.

For the low-income commercial semi-constrained program and constrained program, the average program spending up to 2020 is about $0.15 per cubic metre of natural gas saved.

Exhibit 96 Low-income Commercial Supply Curve: Program Costs for 2015 to 2020

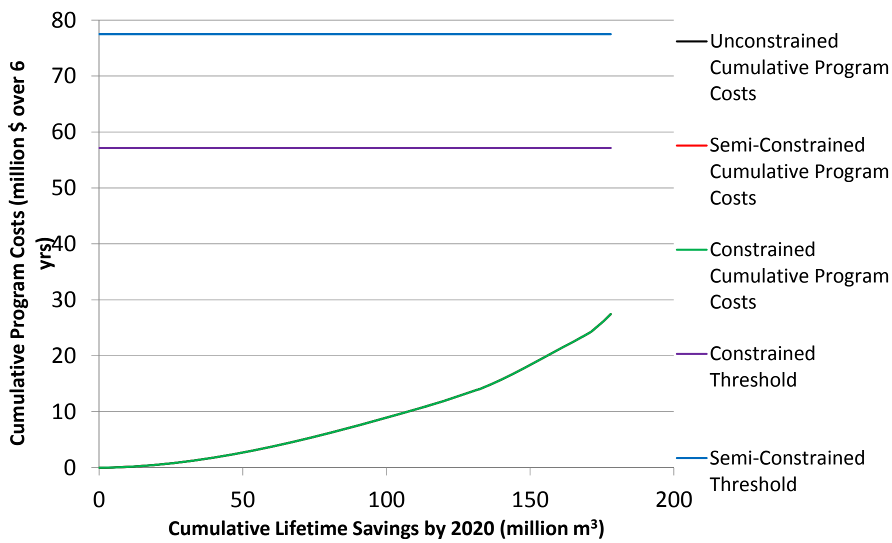


Exhibit 97 Low-income Commercial Achievable Potential Savings and Program Cost Results[72]

Value	Unconstrained		Semi-Constrained		Constrained	
	Year					
	2020	2030	2020	2030	2020	2030
Annual Savings (million m^3/yr.)	15	63	15	63	15	51
Measure Lifecycle Savings (million m^3)	178	1,001	178	1,001	178	872
Value of Savings (million $)	27	169	27	169	27	145
Program Spending to Milestone Year (million $)	27*	171*	27	171	27	131
Average Annual Program Spending (million $/yr.)	5*	11*	5	11	5	8
Average Program Spending up to Milestone Year ($/$m^3$)	0.15*	0.17*	0.15	0.17	0.15	0.15

**Note: These are not specific program costs but are the total costs for the scenario.*

[72] See footnote 64 for details on the values in this table.

5.6.4 Achievable Potential Summary – All Scenarios

Exhibit 98 and Exhibit 99 present a comparison of the reference case, technical, economic, unconstrained, constrained, and semi-constrained achievable potential consumption for the commercial sector. The unconstrained, semi-constrained, and constrained achievable potential scenarios could potentially reduce commercial consumption by 4.5%, 3.1%, and 2.7%, respectively, relative to commercial reference case consumption by 2020, and by 18.2%, 9.3%, and 6.5%, respectively, relative to commercial reference case consumption, by 2030.

Exhibit 98 Commercial Reference, Technical Potential, Economic Potential, and Achievable Potential Scenarios Annual Consumption

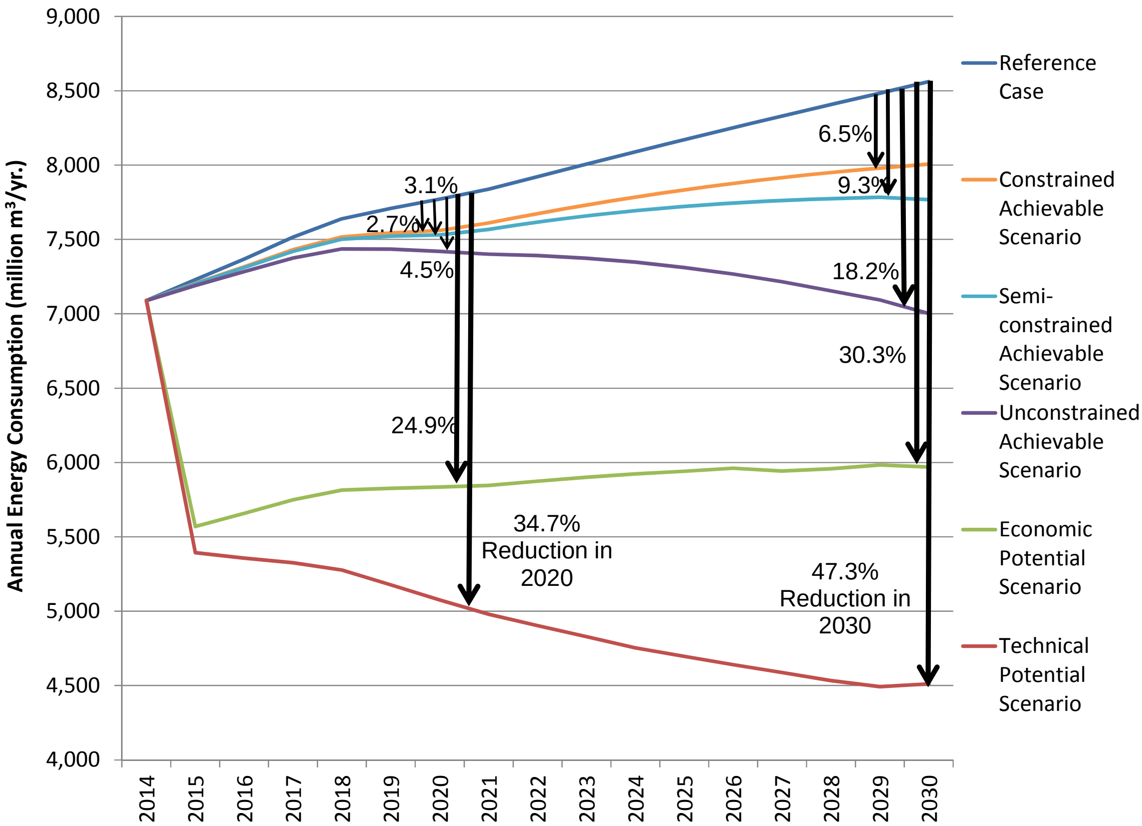


Exhibit 99 Commercial Reference, Technical Potential, Economic Potential, and Achievable Potential Scenarios Annual Savings Relative to Reference Case

Year	Reference Case Use (million m³/yr.)	Technical Potential		Economic Potential		Unconstrained Achievable Potential		Semi-constrained Achievable Potential		Constrained Achievable Potential	
		Absolute Savings (million m³/yr.)	Savings Relative to Reference Case (%)	Absolute Savings (million m³/yr.)	Relative to Reference Case (%)	Absolute Savings (million m³/yr.)	Relative to Reference Case (%)	Absolute Savings (million m³/yr.)	Relative to Reference Case (%)	Absolute Savings (million m³/yr.)	Relative to Reference Case (%)
2015	7,229	1,835	25.4%	1,659	23.0%	39	0.5%	26	0.4%	24	0.3%
2016	7,369	2,012	27.3%	1,711	23.2%	85	1.2%	58	0.8%	52	0.7%
2017	7,515	2,189	29.1%	1,766	23.5%	140	1.9%	95	1.3%	85	1.1%
2018	7,639	2,363	30.9%	1,825	23.9%	203	2.7%	138	1.8%	123	1.6%
2019	7,708	2,532	32.8%	1,881	24.4%	273	3.5%	187	2.4%	165	2.1%
2020	7,771	2,696	34.7%	1,936	24.9%	351	4.5%	241	3.1%	211	2.7%
2025	8,170	3,473	42.5%	2,229	27.3%	860	10.5%	449	5.5%	337	4.1%
2030	8,561	4,051	47.3%	2,592	30.3%	1,560	18.2%	794	9.3%	555	6.5%

5.6.5 Achievable Potential – Unconstrained Scenario

As was shown in Exhibit 99, the total unconstrained achievable potential scenario in the commercial sector results in natural savings of 351 million cubic metres by 2020, or 4.5% of 2020 commercial reference case consumption, and 1,560 million cubic metres by 2030, or 18.2% of 2030 commercial reference case consumption. The remainder of this section provides a breakdown of the commercial unconstrained achievable potential results.

As shown in Exhibit 100 and Exhibit 101, the apartment sub-sector accounts for 21% (75 million cubic metres) of the commercial unconstrained achievable potential by 2020, followed by 17% (60 million cubic metres) of savings potential in offices, 17% (60 million cubic metres) in other, 11% (40 million cubic metres) in education, 10% (34 million cubic metres) in retail, 5% (18 million cubic metres) in hospitals, 5% (17 million cubic metres) in restaurants and less than 5% for each remaining sub-sector. By 2030, the distribution of savings between the sub-sectors remains relatively consistent from 2020.

Space heating accounted for 70% (246 million cubic metres) of commercial unconstrained achievable savings potential by 2020, with service water heating accounting for approximately 28% (99 million cubic metres). The remaining end uses each account for 1% or less of the 2020 unconstrained achievable savings potential. By 2030, the space heating end use accounts for 77% (1,207 million cubic metres) of the commercial unconstrained achievable savings potential, service water heating accounts for 20% (314 million cubic metres), food service accounts for 2% (26 million cubic metres) and the remaining end uses each account for less than 1% of the unconstrained achievable savings potential.

As shown in Exhibit 102 and Exhibit 103, buildings in Enbridge Gas Distribution's service territory accounted for approximately 59% (207 million cubic metres) of the commercial unconstrained achievable savings potential by 2020, with buildings in Union Gas' service territory accounting for the remaining 41% (144 million cubic metres). The distribution of savings between the service areas remains consistent to 2030.

As shown in Exhibit 104 and Exhibit 105, the unconstrained achievable potential savings of existing buildings increased from 139 million cubic metres in 2020 to 1,470 million cubic metres in 2030 while the unconstrained achievable potential savings of new buildings increased from 1 million cubic metres in 2020 to 90 million cubic metres in 2030. Existing buildings accounted for 99% of the commercial unconstrained achievable savings potential in 2020 which decreased to 94% of the commercial unconstrained achievable savings potential in 2030.

Exhibit 100 Graph of Commercial Unconstrained Achievable Potential Savings by Use, Year, and Sub-Sector

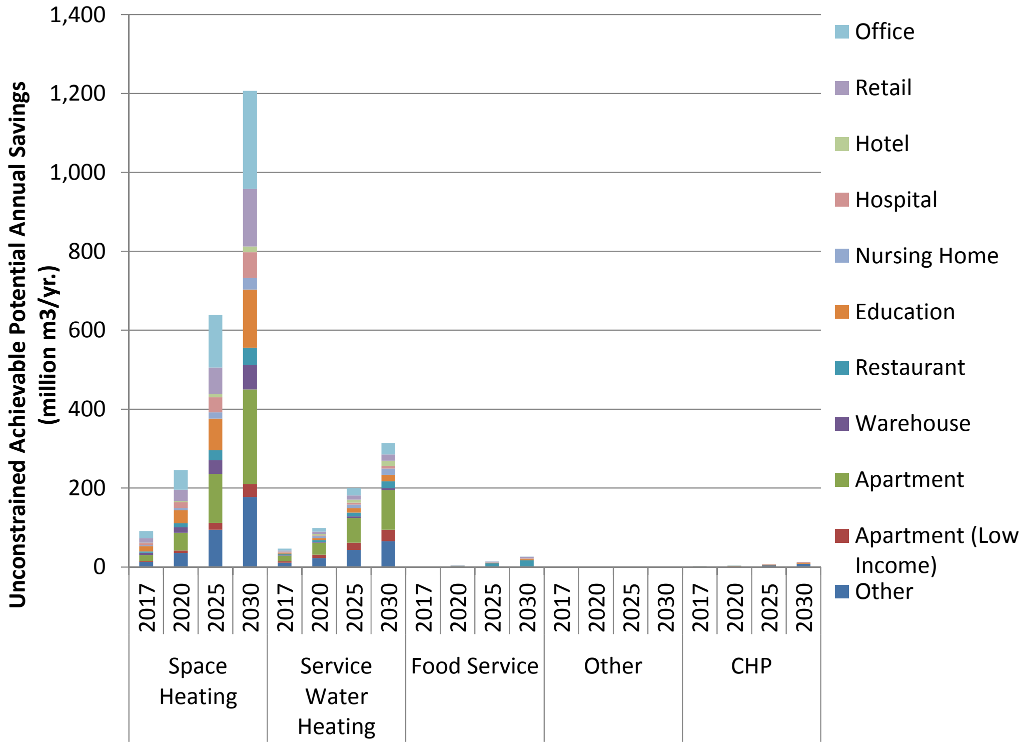


Exhibit 101 Table of Commercial Unconstrained Achievable Potential Savings by Use, Year, and Sub-Sector

End Use	Milestone Year	Savings (million m^3/yr.)											
		Office	Retail	Hotel	Hospital	Nursing Home	Education	Restaurant	Warehouse	Apartment	Apartment (Low Income)	Other	Total
Space Heating	2017	18	11	1	5	2	13	3	6	16	2	13	91
	2020	50	28	3	15	6	33	10	14	45	6	36	246
	2025	133	68	8	38	16	80	25	35	124	17	94	638
	2030	248	146	15	66	29	147	44	62	239	33	177	1,207
Service Water Heating	2017	5	3	2	1	2	3	2	1	14	4	11	46
	2020	10	5	4	2	4	5	4	2	31	9	22	99
	2025	19	10	8	5	9	11	10	4	63	19	43	200
	2030	29	16	13	7	16	17	17	5	100	29	65	314
Food Service	2017	0	0	0	0	0	0	0	-	-	-	0	1
	2020	0	0	0	0	0	0	2	-	-	-	0	3
	2025	0	2	0	0	1	2	8	-	-	-	1	14
	2030	1	3	1	1	1	3	16	-	-	-	1	26
Other	2017	0	0	0	0	0	0	0	0	0	0	0	0
	2020	0	0	0	0	0	0	0	0	0	0	0	0
	2025	0	0	0	0	0	0	0	0	0	0	0	0
	2030	0	0	0	0	0	0	0	0	0	0	0	1
CHP	2017	0	-	0	0	-	0	-	-	0	-	1	1
	2020	0	-	0	1	-	1	-	-	0	-	2	3
	2025	0	-	0	1	-	1	-	-	0	-	4	7
	2030	0	-	0	2	-	2	-	-	0	-	8	12
Grand Total	2017	23	14	3	7	4	16	6	7	30	6	24	140
	2020	60	34	7	18	11	40	17	16	75	15	60	351
	2025	152	80	16	44	26	94	44	38	187	36	142	860
	2030	279	165	28	75	46	169	77	67	339	63	251	1,560

Exhibit 102 Graph of Commercial Unconstrained Achievable Potential Savings by Use, Year, and Utility

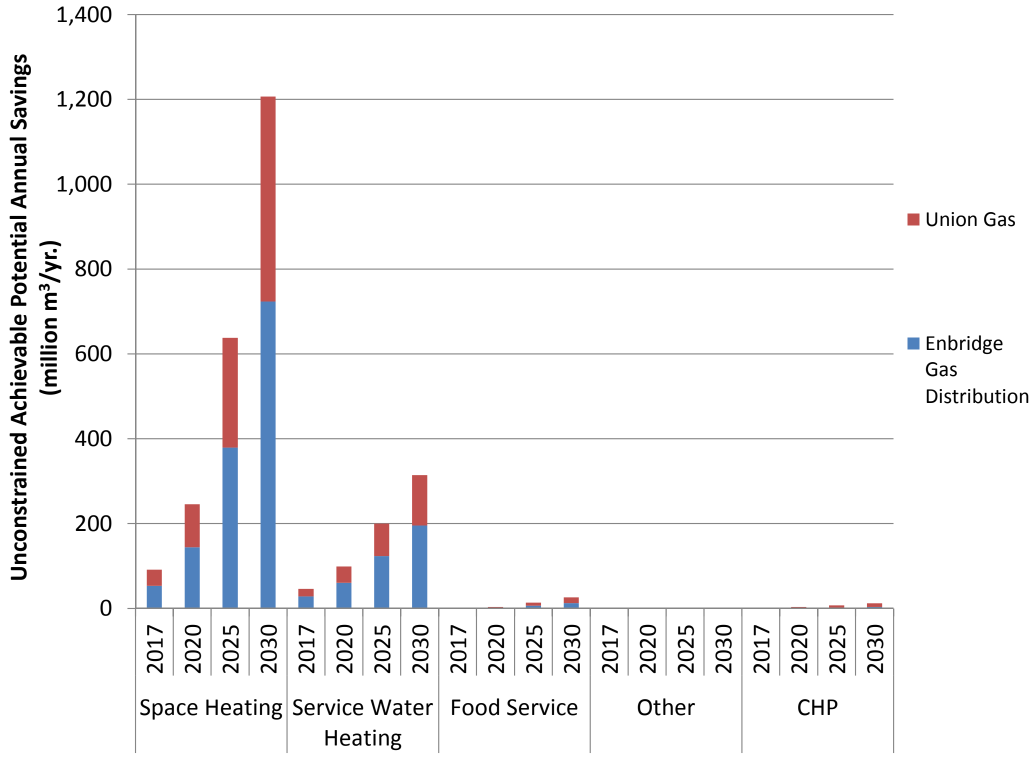


Exhibit 103 Table of Commercial Unconstrained Achievable Potential Savings by Use, Year, and Utility

End Use	Milestone Year	Savings (million m^3/yr.)		
		Enbridge Gas Distribution	Union Gas	Total
Space Heating	2017	53	38	91
	2020	144	102	246
	2025	379	259	638
	2030	724	483	1,207
Service Water Heating	2017	28	18	46
	2020	60	38	99
	2025	123	77	200
	2030	195	119	314
Food Service	2017	0	0	1
	2020	2	2	3
	2025	7	7	14
	2030	12	14	26
Other	2017	0	0	0
	2020	0	0	0
	2025	0	0	0
	2030	0	0	1
CHP	2017	1	1	1
	2020	1	2	3
	2025	2	5	7
	2030	3	9	12
Grand Total	**2017**	**82**	**58**	**140**
	2020	**207**	**144**	**351**
	2025	**511**	**348**	**860**
	2030	**935**	**625**	**1,560**

Exhibit 104 Graph of Commercial Unconstrained Achievable Potential Savings by Use, Year, and Vintage

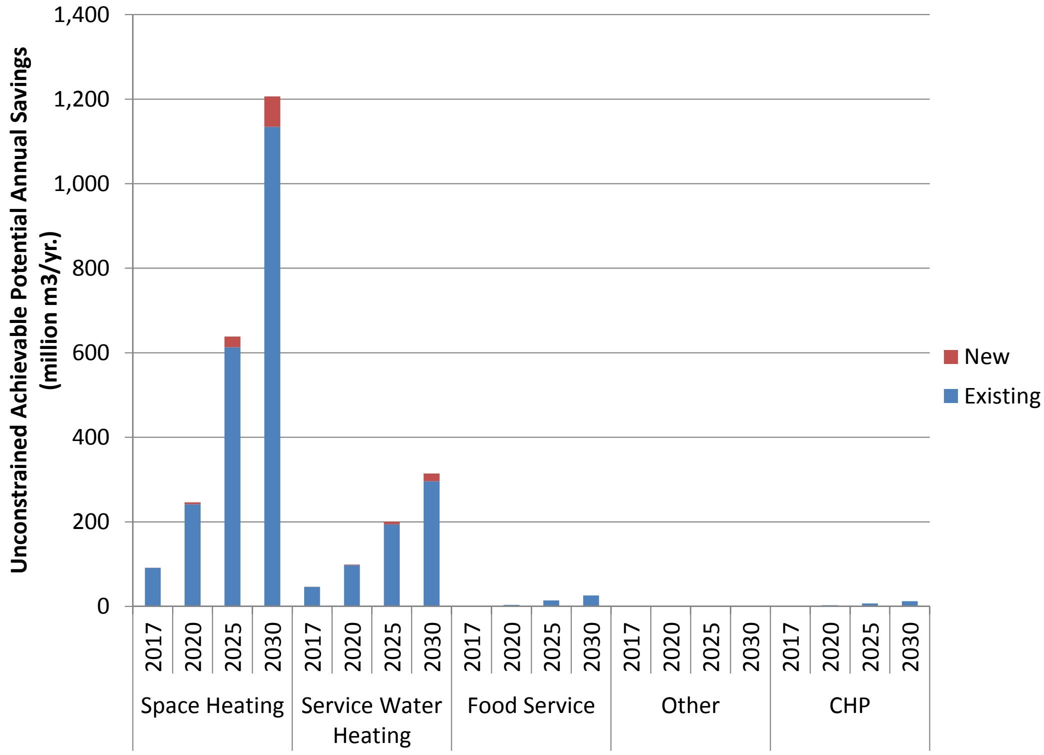


Exhibit 105 Table of Commercial Unconstrained Achievable Potential Savings by Use, Year, and Vintage

End Use	Milestone Year	Savings (million m^3/yr.)		
		Existing	New	Total
Space Heating	2017	91	1	91
	2020	241	4	246
	2025	613	25	638
	2030	1,134	72	1,207
Service Water Heating	2017	46	0	46
	2020	98	1	99
	2025	194	6	200
	2030	296	18	314
Food Service	2017	1	-	1
	2020	3	-	3
	2025	14	-	14
	2030	26	-	26
Other	2017	0	-	0
	2020	0	-	0
	2025	0	-	0
	2030	1	-	1
CHP	2017	1	-	1
	2020	3	-	3
	2025	7	-	7
	2030	12	-	12
Grand Total	**2017**	**139**	**1**	**140**
	2020	**346**	**6**	**351**
	2025	**828**	**31**	**860**
	2030	**1,470**	**90**	**1,560**

5.6.6 Achievable Potential – Semi-constrained Scenario

As was shown in Exhibit 99, the total semi-constrained achievable potential scenario in the commercial sector results in natural savings of 241 million cubic metres by 2020, or 3.1% of 2020 commercial reference case consumption, and 794 million cubic metres by 2030, or 9.3% of 2030 commercial reference case consumption. The remainder of this section provides a breakdown of the commercial semi-constrained achievable potential results.

As shown in Exhibit 106 and Exhibit 107, the apartment sub-sector accounts for 20% (49 million cubic metres) of the commercial semi-constrained achievable potential by 2020, followed by 17% (42 million cubic metres) in other, 16% (38 million cubic metres) of savings potential in offices, 11% (25 million cubic metres) each in education and retail, 6% (15 million cubic metres) in low-income apartments, and 5% or less in the remaining sub-sectors. By 2030, the distribution of savings between the sub-sectors remains relatively consistent from 2020.

Space heating accounted for 66% (158 million cubic metres) of commercial semi-constrained achievable savings potential by 2020, with service water heating accounting for approximately 32% (77 million cubic metres). The remaining end uses each account for 1% or less of the 2020 semi-constrained achievable savings potential. By 2030, the space heating end use accounts for 79% (626 million cubic metres) of the commercial semi-constrained achievable savings potential, service water heating accounts for 18% (145 million cubic metres), food service accounts for 2% (17 million cubic metres) and the remaining end uses each account for less than 1% of the semi-constrained achievable savings potential.

As shown in Exhibit 108 and Exhibit 109, buildings in Enbridge Gas Distribution's service territory accounted for approximately 59% (142 million cubic metres) of the commercial semi-constrained achievable savings potential by 2020, with buildings in Union Gas' service territory accounting for the remaining 41% (99 million cubic metres). The distribution of savings between the utility service areas remains relatively consistent by 2030.

As shown in Exhibit 110 and Exhibit 111, the semi-constrained achievable potential savings of existing buildings increased from 95 million cubic metres in 2020 to 787 million cubic metres in 2030 while the semi-constrained achievable potential savings of new buildings increased from less than 1 million cubic metres in 2020 to 7 million cubic metres in 2030. Existing buildings accounted for more than 99% of the commercial semi-constrained achievable savings potential in 2020 which remained consistent with the commercial semi-constrained achievable savings potential in 2030.

Exhibit 106 Graph of Commercial Semi-Constrained Achievable Potential Savings by Use, Year, and Sub-Sector

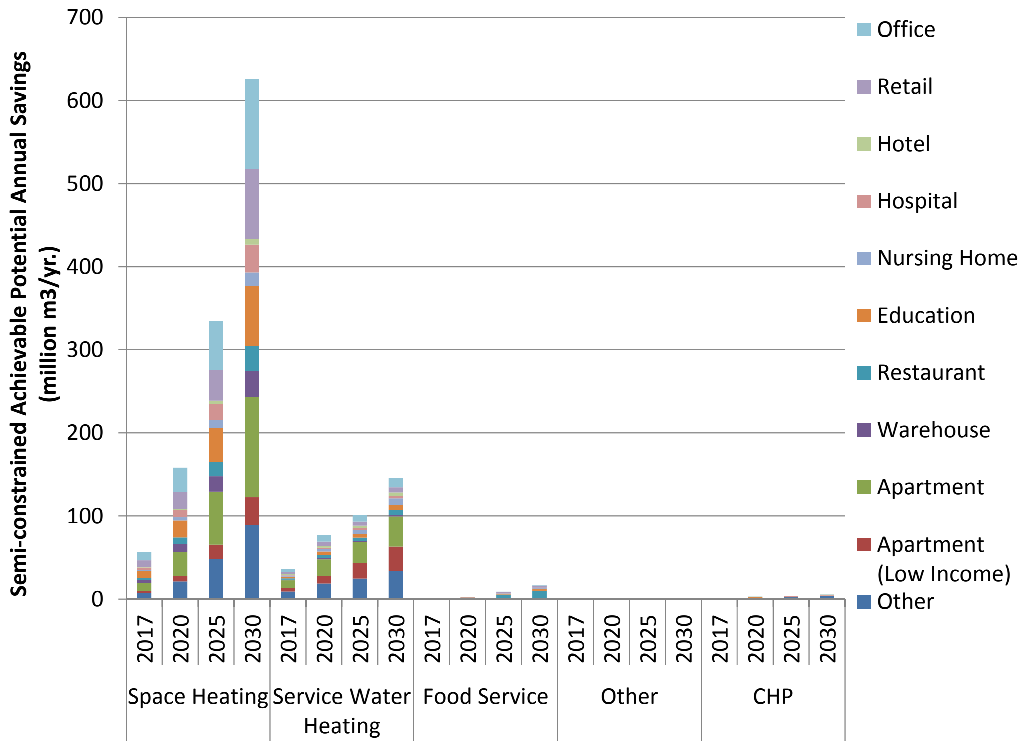


Exhibit 107 Table of Commercial Semi-Constrained Achievable Potential Savings by Use, Year, and Sub-Sector

End Use	Milestone Year	Savings (million m^3/yr.)											
		Office	Retail	Hotel	Hospital	Nursing Home	Education	Restaurant	Warehouse	Apartment	Apartment (Low Income)	Other	Total
Space Heating	2017	10	8	1	3	1	8	3	4	9	2	7	57
	2020	29	20	2	8	4	20	8	10	29	6	21	158
	2025	59	37	4	19	9	41	18	19	64	17	48	335
	2030	108	84	7	34	16	72	30	31	121	33	89	626
Service Water Heating	2017	4	2	1	1	1	2	2	1	9	4	9	36
	2020	8	5	2	2	3	4	4	2	20	9	19	77
	2025	8	5	3	2	5	5	4	2	25	19	25	101
	2030	11	6	4	3	8	7	5	2	36	29	34	145
Food Service	2017	0	0	0	0	0	0	0	-	-	-	0	1
	2020	0	0	0	0	0	0	1	-	-	-	0	2
	2025	0	1	0	0	0	1	5	-	-	-	0	9
	2030	0	2	0	1	1	2	9	-	-	-	1	17
Other	2017	0	0	0	0	0	0	0	0	0	0	0	0
	2020	0	0	0	0	0	0	0	0	0	0	0	0
	2025	0	0	0	0	0	0	0	0	0	0	0	0
	2030	0	0	0	0	0	0	0	0	0	0	0	1
CHP	2017	0	-	0	0	-	0	-	-	0	-	1	1
	2020	0	-	0	1	-	1	-	-	0	-	2	3
	2025	0	-	0	1	-	1	-	-	0	-	2	3
	2030	0	-	0	1	-	1	-	-	0	-	3	5
Grand Total	2017	14	10	2	4	3	10	5	5	19	6	17	95
	2020	38	25	4	11	7	25	13	11	49	15	42	241
	2025	67	43	7	22	15	47	26	20	89	36	75	449
	2030	120	93	12	38	25	82	44	33	157	63	127	794

Exhibit 108 Graph of Commercial Semi-Constrained Achievable Potential Savings by Use, Year, and Utility

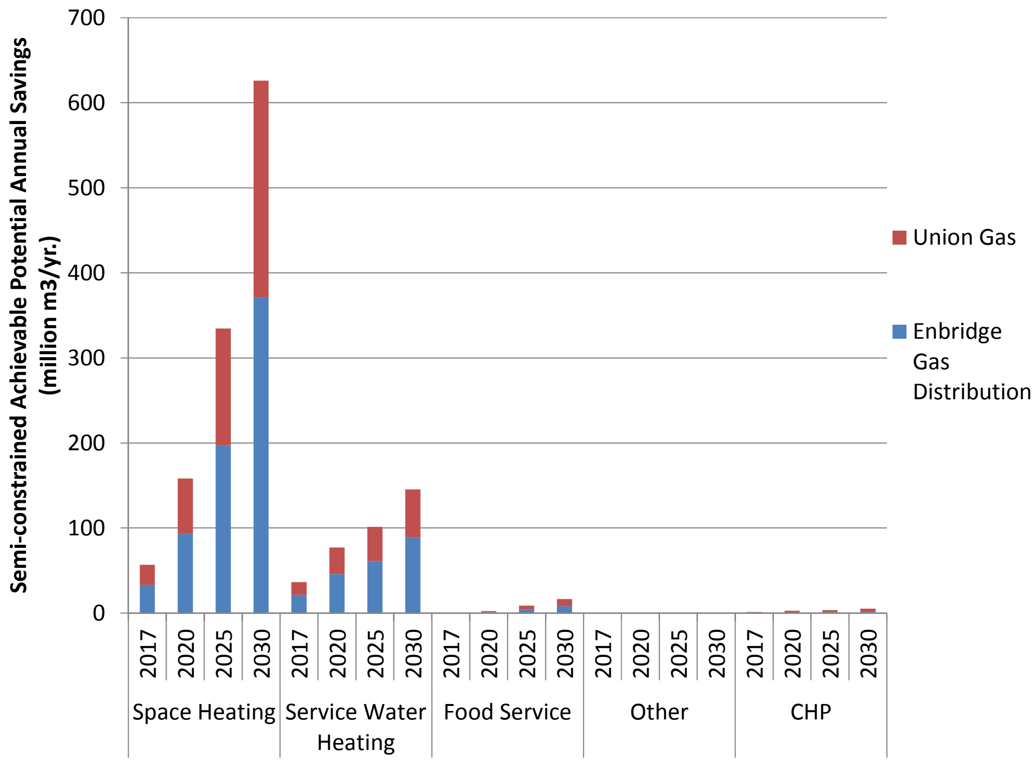


Exhibit 109 Table of Commercial Semi-Constrained Achievable Potential Savings by Use, Year, and Utility

End Use	Milestone Year	Savings (million m^3/yr.)		
		Enbridge Gas Distribution	Union Gas	Total
Space Heating	2017	33	24	57
	2020	93	65	158
	2025	197	138	335
	2030	371	255	626
Service Water Heating	2017	22	15	36
	2020	46	31	77
	2025	61	40	101
	2030	89	57	145
Food Service	2017	0	0	1
	2020	1	1	2
	2025	4	5	9
	2030	8	9	17
Other	2017	0	0	0
	2020	0	0	0
	2025	0	0	0
	2030	0	0	1
CHP	2017	0	1	1
	2020	1	2	3
	2025	1	2	3
	2030	1	4	5
Grand Total	2017	56	40	95
	2020	142	99	241
	2025	264	185	449
	2030	469	325	794

Exhibit 110 Graph of Commercial Semi-Constrained Achievable Potential Savings by Use, Year, and Vintage

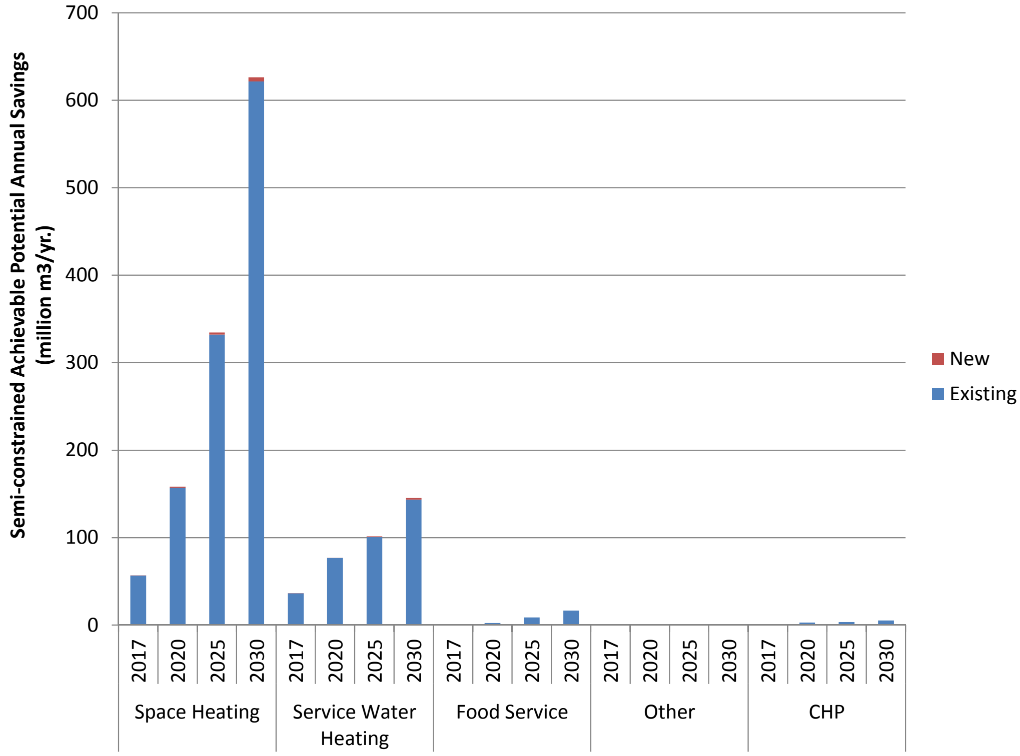


Exhibit 111 Table of Commercial Semi-Constrained Achievable Potential Savings by Use, Year, and Vintage

End Use	Milestone Year	Savings (million m^3/yr.)		
		Existing	New	Total
Space Heating	2017	57	0	57
	2020	157	1	158
	2025	332	3	335
	2030	621	5	626
Service Water Heating	2017	36	0	36
	2020	77	0	77
	2025	100	1	101
	2030	143	2	145
Food Service	2017	1	-	1
	2020	2	-	2
	2025	9	-	9
	2030	17	-	17
Other	2017	0	-	0
	2020	0	-	0
	2025	0	-	0
	2030	1	-	1
CHP	2017	1	-	1
	2020	3	-	3
	2025	3	-	3
	2030	5	-	5
Grand Total	**2017**	**95**	**0**	**95**
	2020	**239**	**2**	**241**
	2025	**445**	**4**	**449**
	2030	**787**	**7**	**794**

5.6.7 Achievable Potential – Constrained Scenario

As was shown in Exhibit 99, the total constrained achievable potential scenario in the commercial sector results in natural savings of 211 million cubic metres by 2020, or 2.7% of 2020 commercial reference case consumption, and 555 million cubic metres by 2030, or 6.5% of 2030 commercial reference case consumption. The remainder of this section provides a breakdown of the commercial constrained achievable potential results.

As shown in Exhibit 112 and Exhibit 113, in 2020 the apartment accounts for 20% (42 million cubic metres) of the commercial constrained achievable potential, followed by 18% of savings potential in other (39 million cubic metres), 15% (31 million cubic metres) in offices, 10% (22 million cubic metres) in education, 10% (21 million cubic metres) in retail, 7% (15 million cubic metres) in low-income apartments, 5% (11 million cubic metres) in restaurants, and less than 5% in each of the remaining sub-sectors. By 2030 the apartment sub-sector grows to account for 24% (131 million cubic metres) of the commercial constrained achievable potential, followed by 18% of savings potential in other (99 million cubic metres), 16% (86 million cubic metres) in offices, 9% (52 million cubic metres) in education, 9% (51 million cubic metres) in low-income apartments, 9% (49 million cubic metres) in retail, and less than 5% in each of the remaining sub-sectors.

Space heating accounted for 62% (130 million cubic metres) of commercial constrained achievable savings potential by 2020, with service water heating accounting for approximately 36% (76 million cubic metres). The remaining end uses each account for 1% or less of the 2020 constrained achievable savings potential. By 2030, the space heating end use accounts for 74% (411 million cubic metres) of the commercial constrained achievable savings potential, service water heating accounts for 23% (126 million cubic metres), food service accounts for 2% (12 million cubic metres) and the remaining end uses each account for less than 1% of the constrained achievable savings potential.

As shown in Exhibit 114 and Exhibit 115, buildings in Enbridge Gas Distribution’s service territory accounted for approximately 58% (123 million cubic metres) of the commercial constrained achievable savings potential by 2020, with buildings in Union Gas’ service territory accounting for the remaining 42% (88 million cubic metres). The distribution of savings between the utility service areas remains relatively consistent by 2030 with Enbridge Gas Distribution’s service territory accounting for 60% (334 million cubic metres) of the commercial constrained achievable potential savings and buildings in Union Gas’ service territory accounting for the remaining 40% (220 million cubic metres).

As shown in Exhibit 116 and Exhibit 117, the constrained achievable potential savings of existing buildings increased from 84 million cubic metres in 2020 to 548 million cubic metres in 2030 while the constrained achievable potential savings of new buildings increased from less than 1 million cubic metres in 2020 to 7 million cubic metres in 2030. Existing buildings accounted for more than 99% of the commercial constrained achievable savings potential in 2020 and accounted for 99% of commercial constrained achievable savings potential in 2030.

Exhibit 112 Graph of Commercial Constrained Achievable Potential Savings by Use, Year, and Sub-Sector

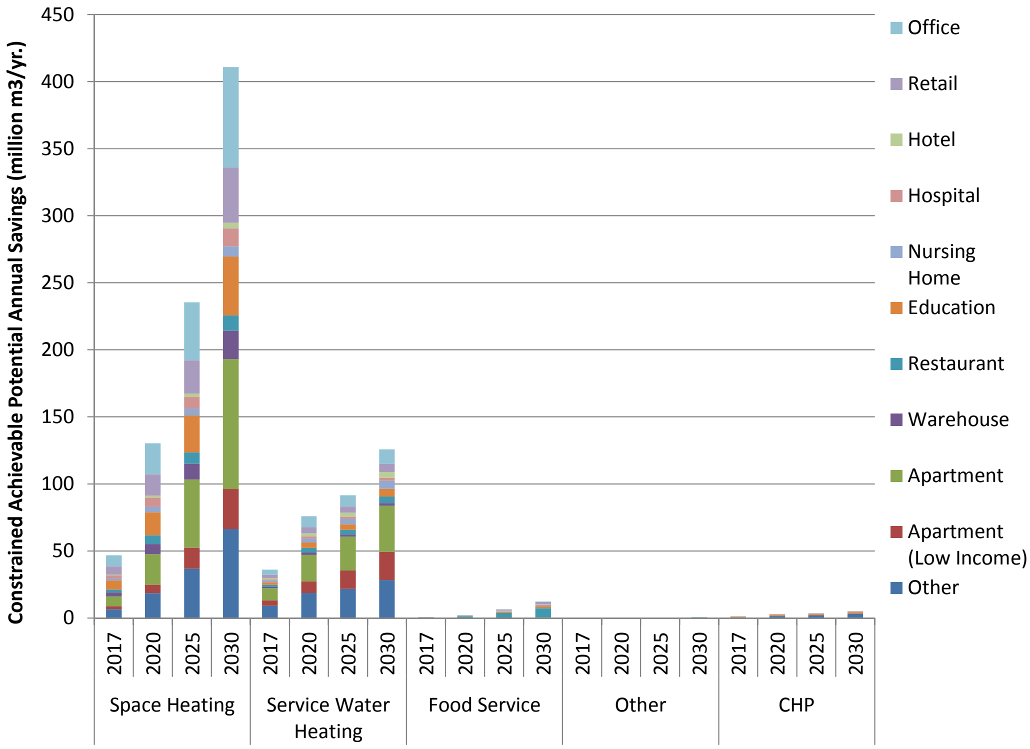


Exhibit 113 Table of Commercial Constrained Achievable Potential Savings by Use, Year, and Sub-Sector

End Use	Milestone Year	Savings (million m³/yr.)											
		Office	Retail	Hotel	Hospital	Nursing Home	Education	Restaurant	Warehouse	Apartment	Apartment (Low Income)	Other	Total
Space Heating	2017	8	6	1	2	1	7	2	3	7	2	7	47
	2020	23	16	2	7	4	17	7	8	23	6	19	130
	2025	43	25	3	9	5	28	8	12	51	16	37	235
	2030	75	41	4	13	8	44	12	21	97	30	66	411
Service Water Heating	2017	4	2	1	1	1	2	2	1	9	4	9	36
	2020	8	5	2	2	3	4	4	2	20	9	19	76
	2025	8	5	3	2	4	4	3	2	25	14	22	92
	2030	11	6	4	2	6	6	5	2	34	21	28	126
Food Service	2017	0	0	0	0	0	0	0	-	-	-	0	0
	2020	0	0	0	0	0	0	1	-	-	-	0	2
	2025	0	1	0	0	0	1	4	-	-	-	0	7
	2030	0	2	0	0	1	1	7	-	-	-	0	12
Other	2017	0	0	0	0	0	0	0	0	0	0	0	0
	2020	0	0	0	0	0	0	0	0	0	0	0	0
	2025	0	0	0	0	0	0	0	0	0	0	0	0
	2030	0	0	0	0	0	0	0	0	0	0	0	1
CHP	2017	0	-	0	0	-	0	-	-	0	-	1	1
	2020	0	-	0	1	-	1	-	-	0	-	2	3
	2025	0	-	0	1	-	1	-	-	0	-	2	3
	2030	0	-	0	1	-	1	-	-	0	-	3	5
Grand Total	2017	12	9	2	3	3	9	4	4	17	6	16	85
	2020	31	21	4	9	7	22	11	9	42	15	39	211
	2025	52	31	6	11	9	33	15	14	76	29	61	337
	2030	86	49	9	17	14	52	23	23	131	51	99	555

Exhibit 114 Graph of Commercial Constrained Achievable Potential Savings by Use, Year, and Utility

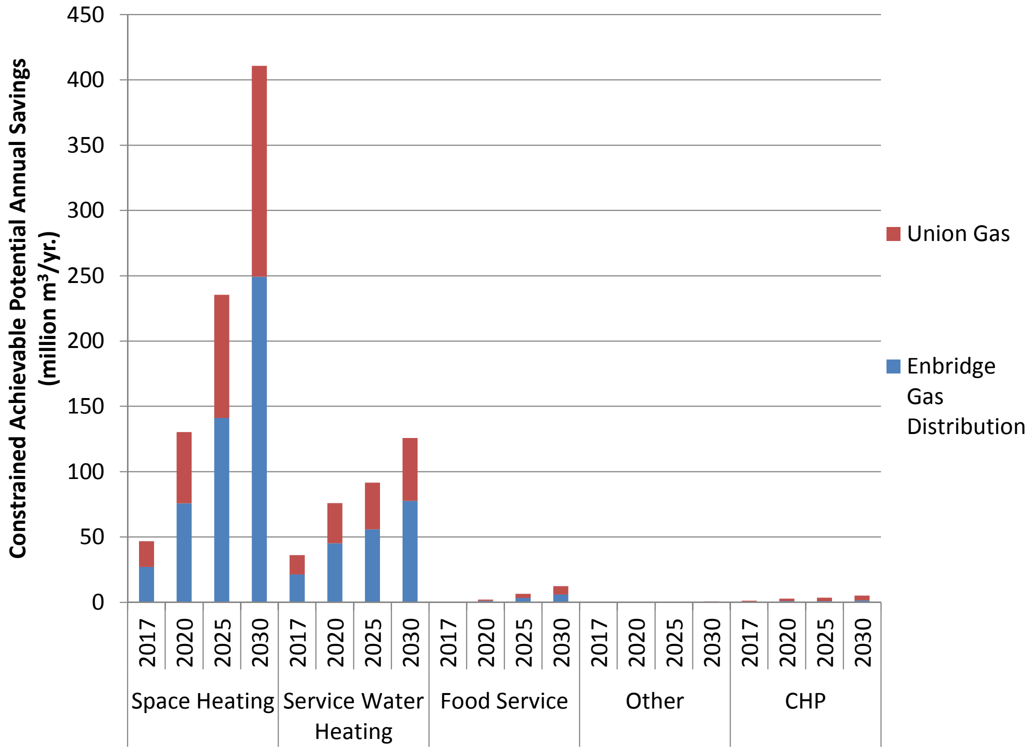


Exhibit 115 Table of Commercial Constrained Achievable Potential Savings by Use, Year, and Utility

End Use	Milestone Year	Savings (million m^3/yr.)		
		Enbridge Gas Distribution	Union Gas	Total
Space Heating	2017	27	20	47
	2020	76	54	130
	2025	141	94	235
	2030	249	162	411
Service Water Heating	2017	21	15	36
	2020	45	31	76
	2025	56	36	92
	2030	78	48	126
Food Service	2017	0	0	0
	2020	1	1	2
	2025	3	3	7
	2030	6	6	12
Other	2017	0	0	0
	2020	0	0	0
	2025	0	0	0
	2030	0	0	1
CHP	2017	0	1	1
	2020	1	2	3
	2025	1	2	3
	2030	1	4	5
Grand Total	2017	49	36	85
	2020	123	88	211
	2025	201	136	337
	2030	334	220	555

Exhibit 116 Graph of Commercial Constrained Achievable Potential Savings by Use, Year, and Vintage

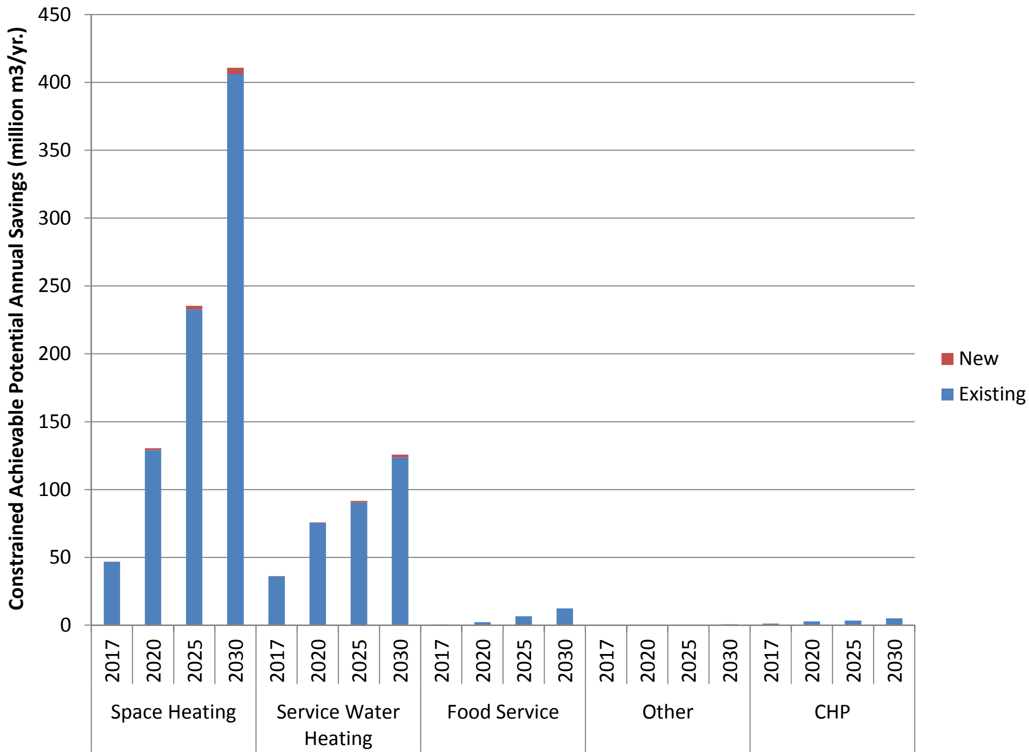


Exhibit 117 Table of Commercial Constrained Achievable Potential Savings by Use, Year, and Vintage

End Use	Milestone Year	Savings (million m^3/yr.)		
		Existing	New	Total
Space Heating	2017	47	0	47
	2020	129	1	130
	2025	233	3	235
	2030	406	5	411
Service Water Heating	2017	36	0	36
	2020	75	0	76
	2025	91	1	92
	2030	124	2	126
Food Service	2017	0	-	0
	2020	2	-	2
	2025	7	-	7
	2030	12	-	12
Other	2017	0	-	0
	2020	0	-	0
	2025	0	-	0
	2030	1	-	1
CHP	2017	1	-	1
	2020	3	-	3
	2025	3	-	3
	2030	5	-	5
Grand Total	**2017**	**84**	**0**	**85**
	2020	**210**	**2**	**211**
	2025	**334**	**4**	**337**
	2030	**548**	**7**	**555**

5.7 GHG Emission Reductions

The commercial sector GHG emission reductions, which were calculated according to the methodology presented in section 2.9, are presented in Exhibit 118. The results show that the economic potential GHG emission reductions range from approximately 3,606 million kg CO_2 in 2017 to 4,828 million kg CO_2 in 2030. The unconstrained achievable potential GHG emission reductions range from 655 million kg CO_2 in 2020 to 2,906 million kg CO_2 in 2030.

Exhibit 118 Commercial GHG Emission Reductions

Year	Reference Case Emissions (million kg CO_2/yr)	Technical Potential		Economic Potential		Unconstrained Achievable Potential		Semi-constrained Achievable Potential		Constrained Achievable Potential	
		GHG Reduction (million kg CO_2/yr.)	Savings Relative to Reference Case (%)	GHG Reduction (million kg CO_2/yr.)	Savings Relative to Reference Case (%)	GHG Reduction (million kg CO_2/yr.)	Savings Relative to Reference Case (%)	GHG Reduction (million kg CO_2/yr.)	Savings Relative to Reference Case (%)	GHG Reduction (million kg CO_2/yr.)	Savings Relative to Reference Case (%)
2015	13,467	3,419	25.4%	3,091	23.0%	72	0.5%	49	0.4%	44	0.3%
2016	13,728	3,749	27.3%	3,187	23.2%	159	1.2%	108	0.8%	96	0.7%
2017	14,000	4,077	29.1%	3,290	23.5%	261	1.9%	177	1.3%	158	1.1%
2018	14,232	4,402	30.9%	3,400	23.9%	378	2.7%	258	1.8%	228	1.6%
2019	14,361	4,717	32.8%	3,504	24.4%	509	3.5%	348	2.4%	307	2.1%
2020	14,477	5,023	34.7%	3,606	24.9%	655	4.5%	449	3.1%	394	2.7%
2025	15,221	6,470	42.5%	4,153	27.3%	1,602	10.5%	836	5.5%	628	4.1%
2030	15,949	7,546	47.3%	4,828	30.3%	2,906	18.2%	1,479	9.3%	1,033	6.5%

5.8 Sensitivity Analysis

This section presents the results of the commercial sensitivity analysis based on the methodology discussed in section 2.10.

As shown in Exhibit 119, the increase in avoided costs would result in an increase in economic potential and unconstrained achievable potential, as more measures would pass the TRC-plus test. Increasing the avoided costs by 50% increases the economic potential savings by 29% in 2020 and 43% in 2030. It also increases the unconstrained achievable potential savings by 14% in 2020 and 17% in 2030. Similar to the results for the residential sector, the additional measures were relatively expensive compared to the measures that were already part of the original achievable constrained and semi-constrained scenarios. Therefore, any of the measures that were already part of the original achievable constrained and semi-constrained scenarios were not displaced because savings from these scenarios are limited by the same constrained and semi-constrained budgets as in the default assumptions case.

As is also shown in Exhibit 119, a 20% increase in participation rates increases the unconstrained potential achievable results by 11% in 2020 and 10% in 2030. The participation sensitivity results for the semi-constrained scenario shows an increase of 7% in 2020 and 5% in 2030. For the same participation analysis, there is an increase in the savings potential for the constrained scenario results by 12% in 2020 and 0.4% in 2030.

Exhibit 119 Commercial Sensitivity Analysis Results

Scenario	Annual Savings (million m^3)		Avoided Cost - 50% Increase				20% Participation Sensitivity			
			Annual Savings (million m^3)		% Change		Annual Savings (million m^3)		% Change	
	2020	2030	2020	2030	2020	2030	2020	2030	2020	2030
Economic Potential	1,936	2,592	2,493	3,710	29%	43%				
Unconstrained Potential	351	1,560	400	1,824	14%	17%	391	1,715	11%	10%
Semi-Constrained Potential	241	794					259	834	7%	5%
Constrained Potential	211	555					236	557	12%	0.4%

6 Industrial Sector

6.1 Measure Potential Savings

This chapter describes the industrial measure potential savings using the methodology outlined in section 2.1 of the methodology chapter.

Exhibit 120 presents the maximum potential savings associated with each measure on an individual basis at the maximum possible rate of adoption, with colour-coding to differentiate those measures whose average TRC-plus ratio is greater than 1.0 versus less than 1.0. As was previously noted, a TRC-plus ratio that is greater than 1.0 indicates that a measure is economic, from the society resource use perspective. As shown in Exhibit 120, the only industrial measure that did not have an average TRC-plus ratio greater than one was regenerative thermal oxidizers.

In all cases, the measure savings are calculated relative to a reference case that includes natural changes in the measure market penetration rate, but these savings do not account for the potential interactive effects with any other measure in the chart, or that some measures will compete with others, depending on customer preferences. These interactive effects are taken into account in the analysis of technical, economic, and achievable potentials in later chapters, but maximum savings are shown here for reference. The savings potential of each measure are adjusted appropriately in determining the Ontario-wide technical potential savings.

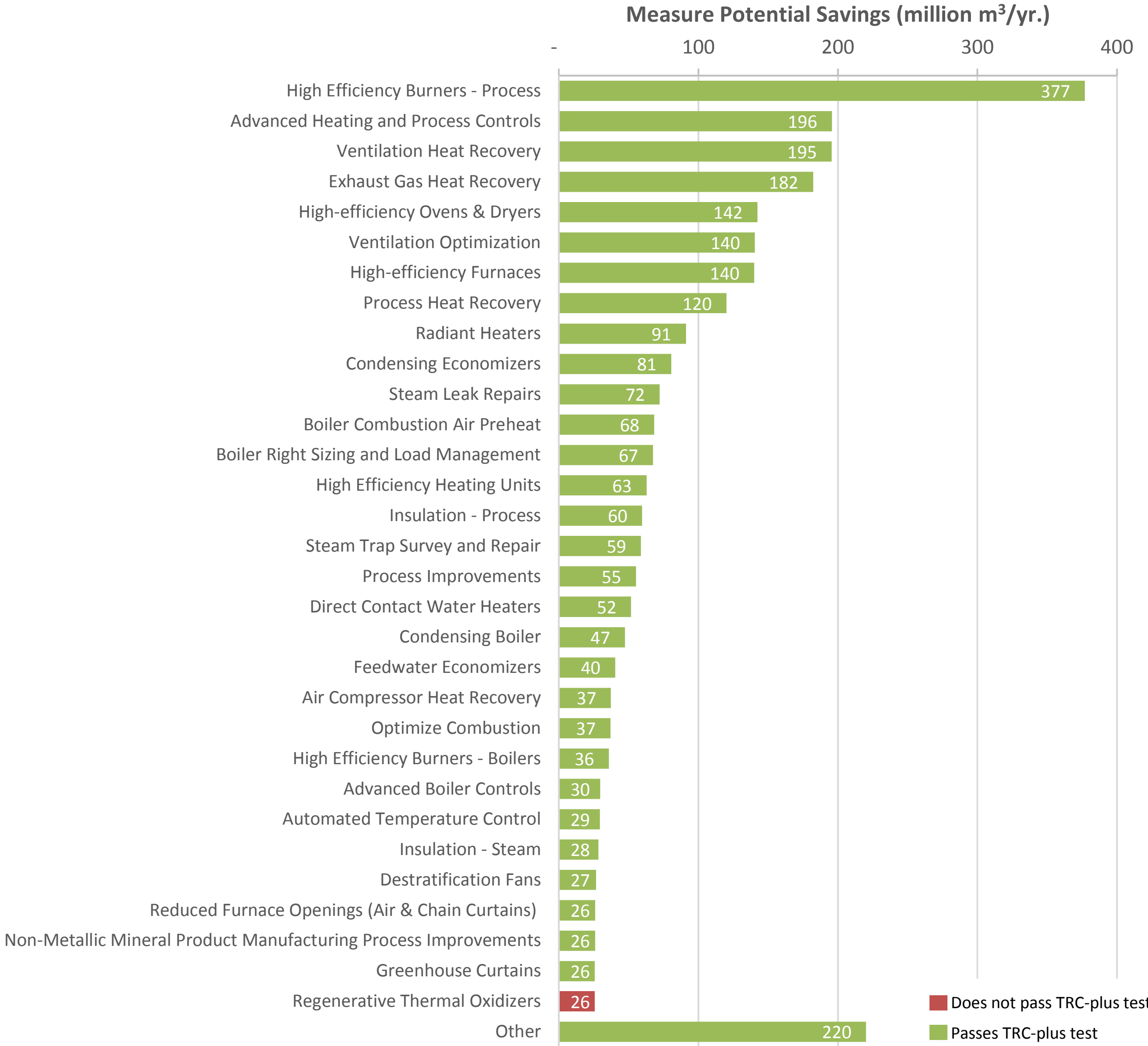
The industrial sector model includes assumptions for reference case market penetration of measures, which begin with an assumed market penetrations in the base year of the study. Measure applicability is also established for each industrial measure, specific to equipment size-categories and sub-sectors. ICF's experience formed the basis of these model inputs and were supplemented by feedback from utility experts and secondary sources.

Certain measures that would require longer lead times for design and implementation are assumed to ramp up to full market penetration over the first few years of the study, as opposed to the immediate implementation normally assumed in the Technical potential scenario.

Exhibit 121 presents the results of a financial assessment of each measure in 2015. The TRC-plus column presents the benefit/cost ratio for each measure based on the TRC-plus test described previously. The TRC-plus test is performed separately for each industrial subsector and equipment size and the average value is presented here. This test is also repeated in each year so that even if a measure fails the TRC-plus test in 2015, it may be included in a future year if it passes the TRC-plus test in that year.

The payback column presents financial results from a customer perspective. The upfront capital cost of the measure is divided by annual customer cost savings in reduced operating and maintenance, natural gas, electricity, and water consumption, to obtain the number of years for the measure to pay back its upfront cost. The calculation is repeated for each sub-sector and equipment size and the average value is presented here.

Exhibit 120 Industrial Measure Potential Savings in 2030



Note:

1) *The measure that is red does not pass the TRC-plus test and the measures that are green do. The "Other" category is a sum of the measures with potential savings of 24 million cubic metres or less. All of the measures in this category pass the TRC-plus test.*

Exhibit 121 Industrial Measure Details

#	Measure Name	TRC-Plus	Simple Payback
1	Boiler Right Sizing and Load Management	275.8	-
2	Reduce Boiler Steam Pressure	190.5	0.1
3	High Efficiency Burners (Process)	34.1	0.8
4	High-efficiency Furnaces	29.3	2.4
5	Exhaust Gas Heat Recovery	27.9	1.1
6	Regenerative Thermal Oxidizers	26.7	0.7
7	High-efficiency Ovens & Dryers	21.0	3.3
8	Reduced Furnace Openings (Air & Chain Curtains)	18.0	1.0
9	Ventilation Optimization	17.5	1.1
10	Minimize Door Openings	17.0	1.1
11	Direct Contact Water Heaters	15.8	1.4
12	Non-Metallic Mineral Product Manufacturing Process Improvements	15.1	1.2
13	Insulation (Process)	14.7	1.6
14	Optimize Combustion	11.9	0.6
15	Air Compressor Heat Recovery	11.9	1.6
16	Advanced Heating and Process Controls	10.9	1.9
17	Greenhouses Other EE Upgrades	10.9	2.3
18	Automated Temperature Control	10.2	1.8
19	Steam Trap Survey and Repair	9.1	1.0
20	Insulation (Steam Systems)	8.8	2.3
21	Process Heat Recovery	8.0	3.0
22	Automated Blowdown Control	8.0	1.9
23	Food and Beverage Manufacturing Process Improvements	7.4	4.8
24	Steam Leak Repairs	7.1	1.8
25	High Efficiency Burners (Boilers)	6.8	4.3
26	High Efficiency Heating Units	6.7	2.8
27	Greenhouse Envelope Improvements	6.6	1.1
28	Gas Turbine Optimization	6.5	0.1
29	Ventilation Heat Recovery	6.2	3.0
30	Primary Metal Manufacturing Process Improvements	5.6	3.9
31	Condensing Economizers	5.5	3.9
32	Boiler Tune Up	5.3	1.3
33	Condensing Boiler	5.2	3.3
34	Blowdown Heat Recovery	5.0	3.9
35	Advanced Boiler Controls	5.0	3.6
36	Feedwater Economizers	4.9	4.4
37	Warehouse Loading Dock Seals	4.7	4.0
38	Asphalt and Cement Manufacturing Process Improvements	4.5	5.1
39	Fabricated Metal Manufacturing Process Improvements	4.5	6.8
40	Transportation and Machinery Manufacturing Process Improvements	4.5	4.9
41	Process Improvements	4.3	5.7
42	Destratification Fans	4.0	4.7
43	Minimize Deaerator Vent Losses	3.9	3.7
44	Greenhouse Curtains	3.5	3.8
45	Chemical Manufacturing Process Improvements	3.0	7.9
46	Improved Building Envelope	2.9	6.4
47	Boiler Combustion Air Preheat	2.9	7.2
48	Radiant Heaters	2.9	6.6
49	Pulp and Paper Process Improvements	2.7	6.2
50	Condensate Return	2.3	9.4
51	Burn Digester Gas in Boilers	1.8	0.3
52	Mining Process Improvements	1.7	Exceeds measure life
53	Steam Turbine Optimization	1.7	0.4
54	Refining Process Improvements	1.7	10.6
55	Solar Walls	1.3	26.4

6.2 Base Year Natural Gas Energy Use

6.2.1 Industrial Sector Segmentation

The industrial sector is broken out into the following sub-sectors:

- Cement and Asphalt Manufacturing
- Chemical Manufacturing
- Fabricated Metal Manufacturing
- Food and Beverage Manufacturing
- Greenhouses
- Non-Metallic Mineral Product Manufacturing
- Mining, Quarrying, and Oil and Gas Extraction
- Miscellaneous Manufacturing
- Pulp, Paper, and Wood Products Manufacturing
- Petroleum and Coal Product Manufacturing
- Primary Metal Manufacturing
- Transportation and Machinery Manufacturing
- Utilities Sub-Sector

The table below lists the applicable NAICS code for each sub-sector and provides examples of the types of industries in each sub-sector.

Sub-sector	NAICS	Examples of Industry Types
Cement and Asphalt Manufacturing	3273, 32412	Plants producing cement, concrete, or asphalt.
Chemical Manufacturing	325	Plants producing petrochemicals, specialty chemicals, pharmaceuticals, paints, or pesticides.
Fabricated Metal Manufacturing	332	Machine shops, metal treating facilities, and plants producing metal products through forging, stamping, rolling, drawing, extruding, alloying, or casting processes.
Food and Beverage Manufacturing	311, 312	Breweries, wineries, bakeries, and plants producing/processing dairy products, fruit/vegetables, meat, non-alcoholic beverages, and all other foods.
Greenhouses	1114	Establishments primarily engaged in growing crops of any kind under cover. Excludes other agriculture.
Non-Metallic Mineral Product Manufacturing	3271, 3272, 3274, 3279	Plants producing glass, ceramics, lime, gypsum, and related building-products.
Mining, Quarrying, and Oil and Gas Extraction	21	Mines, quarries, oil and gas wells, and related support activities.
Miscellaneous Manufacturing	339, 326, 334, 337, 313, 314, 315, 316, 11	All other industrial and agricultural facilities. Includes facilities producing, plastic and rubber products, computers, electronics, furniture, textiles, livestock, fruit, vegetables, grains, and other products. Also includes forestry, fishing, and hunting services.
Pulp, Paper, and Wood Products Manufacturing	322, 321, 323	Pulp and paper mills, sawmills, and manufacturing of paper products and wood panel products.
Petroleum and Coal Product Manufacturing	32411, 32419	Petroleum refining and associated products, other than asphalt production.

Sub-sector	NAICS	Examples of Industry Types
Primary Metal Manufacturing	331	Iron and steel mills, production and processing of aluminum and other metals, foundries, and production of some steel/iron products (pipe, tube, wire, etc.).
Transportation and Machinery Manufacturing	333, 334	Manufacturing of motor vehicles, vehicle parts, aerospace products and parts, industrial machinery, and HVAC equipment.
Utilities Sub-sector	22	Electricity generating stations, natural gas distribution facilities, and water and sewage treatment facilities.

6.2.2 Sub-sector Organization

Most sub-sectors align with categories of industrial customers used by the utilities[73]. Some sub-sectors aggregate several customer categories, while in one case a customer category was divided into several sub-sectors, based on ICF's experience.

6.2.3 End Uses

The industrial sector includes the following end uses:

- Direct Heating: Furnaces, Ovens, Kilns, and Dryers
- Steam and Hot Water Systems: Process Boilers and Water Heaters
- Heating and Ventilation: Space Heating and Ventilation Systems
- Gas Turbine: Gas Turbines
- Steam Turbine: Steam Turbines
- CHP Steam: Steam from Combined Heat and Power
- CHP Electricity: Electricity from Combined Heat and Power
- Other: Miscellaneous

6.2.4 End Use Fuel Share Data

An end use breakdown was developed for each of the listed industrial sub-sectors. Manufacturing Energy Consumption Survey (MECS) data provided by the U.S. Energy Information Administration (EIA) forms the basis of the end use breakdowns. MECS breakdowns were adjusted to account for actual penetration of cogeneration in Ontario, using data from the Canadian Cogeneration Database, provided by the Canadian Industrial Energy End use Data and Analysis Centre (CIEEDAC). ICF's experience with industrial energy use was also taken into consideration.

6.2.5 Equipment Energy Consumption

The sub-sector and end use breakdowns discussed above are used in the model to apportion the base year consumption reference case forecast such that specific measures can be applied to the appropriate natural gas volumes. In addition, a breakdown of equipment sizes was developed for each sub-sector, further splitting the end use gas consumption volumes into small-, medium-, and large-sized equipment.

Typical equipment energy consumption ratings were also established for the three size categories. Along with the equipment ratings, expected hours of operation and load factors were established, which form the basis against which industrial conservation measures are applied.

[73] Enbridge's Rate 125 customers were excluded because they are not eligible to participate in DSM.

6.2.6 Base Case Estimates

Exhibit 122 through Exhibit 125 present the estimated base year consumption of natural gas, broken out by sub-sector, end use, and utility.

Exhibit 122 Industrial Distribution of Natural Gas Consumption by Sub-sector in the Base Year (2014)

As shown in Exhibit 122 the utilities sub-sector accounts for the largest share of natural gas use within the industrial sector (20%), followed by chemical manufacturing (16%), primary metal manufacturing (15%), and mining, quarrying, and oil and gas extraction (10%).

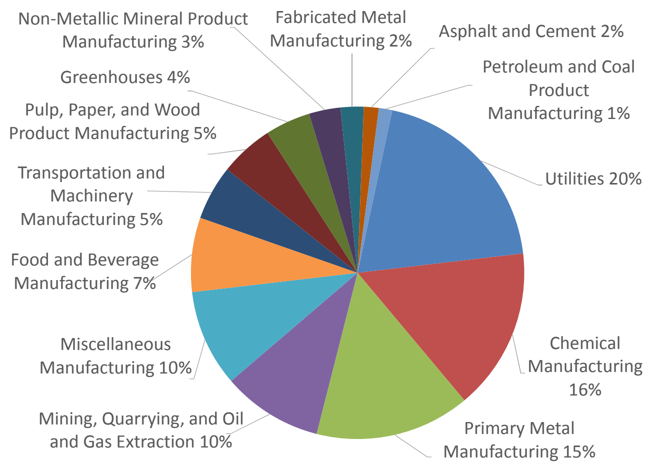


Exhibit 123 Industrial Distribution of Natural Gas Consumption by End Use in the Base Year (2014)

As shown in Exhibit 123, direct heating is the largest end use, accounting for about 42% of industrial sector natural gas use, followed by steam and hot water systems (21%), gas turbines (13%), heating and ventilation (11%), steam turbines (7%), CHP steam (4%), CHP electricity (1%), and other (1%).

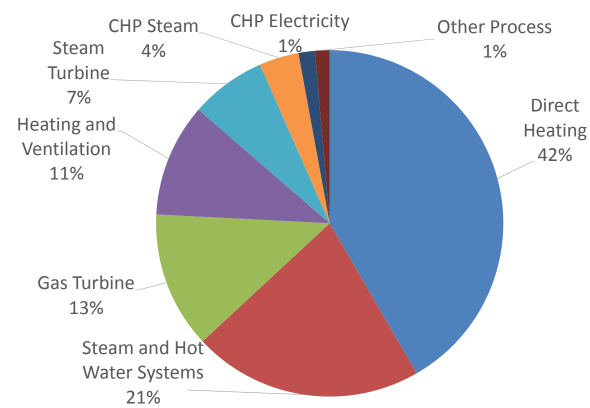


Exhibit 124 Industrial Distribution of Natural Gas Consumption by Utility in the Base Year (2014)

As shown in Exhibit 124 large volume Union Gas customers account for 52% of natural gas consumption in the base year, followed by non-large volume Union Gas customers at 27%, and Enbridge Gas Distribution customers at 21%.

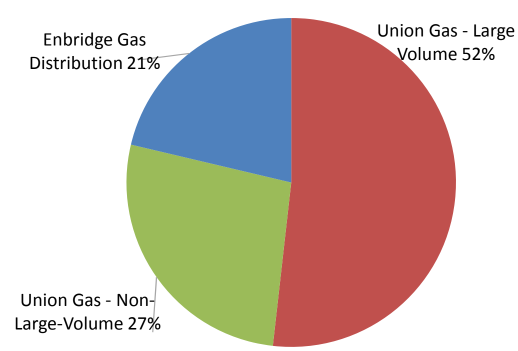


Exhibit 125 Industrial Natural Gas Consumption by Sub-sector and Utility in the Base Year (2014)

Sub-sector	Base Year Consumption, 2014 (million m^3)		
	Enbridge Gas Distribution	Union Gas	Total
Utilities	312.31	1,680	1,992
Chemical Manufacturing	384	1,203	1,587
Primary Metal Manufacturing	124	1,389	1,513
Mining, Quarrying, and Oil and Gas Extraction	9	972	981
Miscellaneous Manufacturing	383	565	948
Food and Beverage Manufacturing	274	453	728
Transportation and Machinery Manufacturing	137	397	534
Pulp, Paper, and Wood Product Manufacturing	158	368	526
Greenhouses	40	402	442
Non-Metallic Mineral Product Manufacturing	95	213	308
Fabricated Metal Manufacturing	127	98	225
Asphalt and Cement	78	67	146
Petroleum and Coal Product Manufacturing	21	109	129
Grand Total	2,143	7,917	10,060

6.3 Reference Case

6.3.1 Reference Case Forecast of Natural Gas Use

Exhibit 126 through Exhibit 129 present the estimated reference case consumption of natural gas, broken out by sub-sector, and then by end use.

Overall, the industrial reference forecast of natural gas in Ontario is expected to rise from approximately 10,060 million cubic metres in 2014 to 10,450 million cubic metres in 2020 and 10,518 million cubic metres in 2030 in the absence of new conservation programs, an increase of approximately 5%, with some fluctuations expected by the utilities in the early years of the study. These fluctuations are largely due to expected power generator contract renewals and new resources coming online or going offline.

As shown in Exhibit 126 and Exhibit 127, in the reference case for 2020, chemical manufacturing (1,955 million cubic metres or 19%) overtakes the utilities sub-sector (1,903 million cubic metres or 18%) to account for the largest share of natural gas use in the industrial sector, followed by primary metal manufacturing (1,339 million cubic metres or 13%), and mining, quarrying, and oil and gas extraction (1,019 million cubic metres or 10%).

Similarly, in 2030 chemical manufacturing (1,995 million cubic metres or 19%) continues to represent the largest share of natural gas use in the industrial sector, followed by the utilities sub-sector (1,903 million cubic metres or 18%), the primary metal manufacturing (1,341 million cubic metres or 13%), and mining, quarrying, and oil and gas extraction (1,019 million cubic metres or 10%).

As shown in Exhibit 128 and Exhibit 129, in the reference case for 2020, direct heating remains the largest end use, accounting for about 4,255 million cubic metres or 41% of industrial sector natural gas use, followed by steam and hot water systems (2,341 million cubic metres or 22%), gas turbines (1,225 million cubic metres or 12%), and heating and ventilation (1,133 million cubic metres or 11%). The remaining 1,451 million cubic metres or 14% are consumed by steam turbines, CHP Steam, CHP electricity, and other process uses.

By 2030 this end use breakdown is expected to remain largely the same, with only the share of natural gas consumed by CHP steam increasing by 1% and the share of natural gas consumed by steam turbines decreasing by 1%.

Exhibit 126 Graph of Industrial Reference Case Natural Gas Consumption by Sub-sector and Year

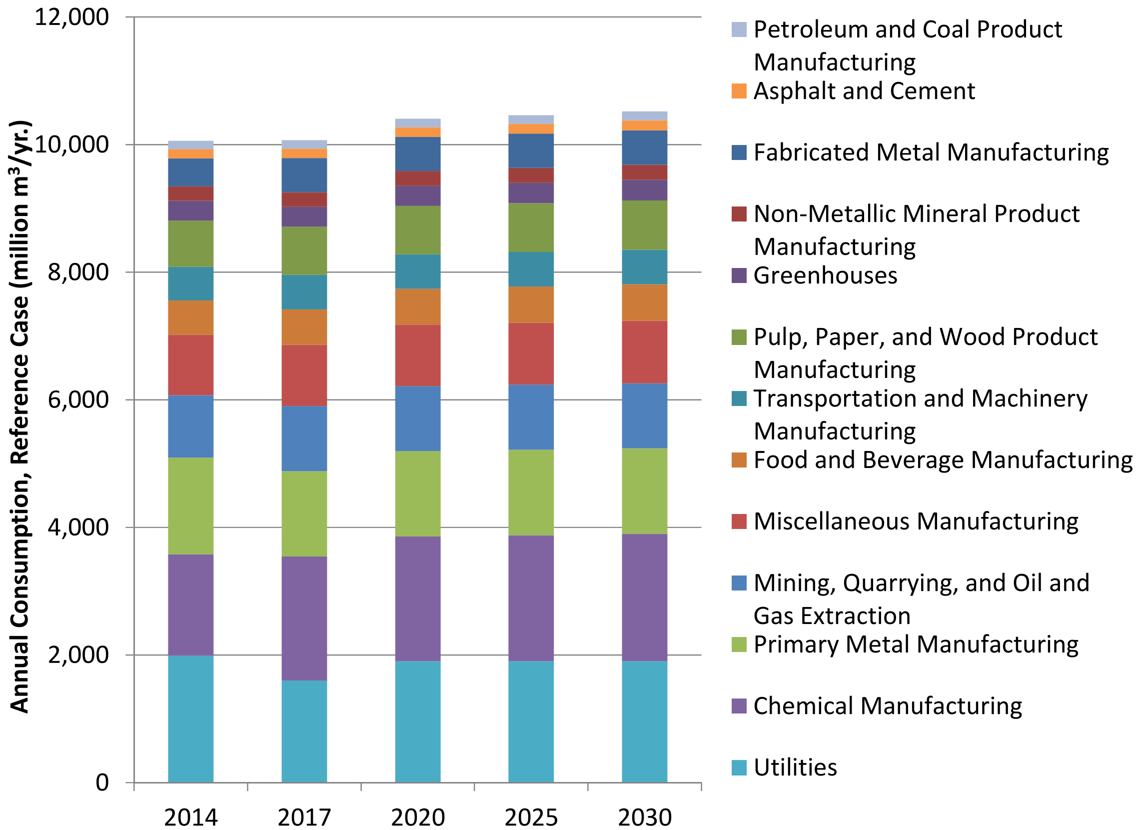


Exhibit 127 Table of Industrial Reference Case Natural Gas Consumption by Sub-sector and Year

Sub-Sector	Consumption (million m^3/yr.)				
	2014	2017	2020	2025	2030
Utilities	1,992	1,601	1,903	1,903	1,903
Chemical Manufacturing	1,587	1,943	1,955	1,975	1,995
Primary Metal Manufacturing	1,513	1,339	1,339	1,340	1,341
Mining, Quarrying, and Oil and Gas Extraction	981	1,019	1,019	1,019	1,019
Miscellaneous Manufacturing	948	961	965	973	980
Food and Beverage Manufacturing	534	556	560	566	573
Transportation and Machinery Manufacturing	526	540	540	540	540
Pulp, Paper, and Wood Product Manufacturing	728	754	759	767	774
Greenhouses	308	313	315	319	322
Non-Metallic Mineral Product Manufacturing	225	229	231	234	237
Fabricated Metal Manufacturing	442	534	535	537	539
Asphalt and Cement	146	150	152	155	158
Petroleum and Coal Product Manufacturing	129	131	133	135	137
Total	10,060	10,069	10,405	10,461	10,518

Exhibit 128 Graph of Industrial Reference Case Natural Gas Consumption by End Use and Year

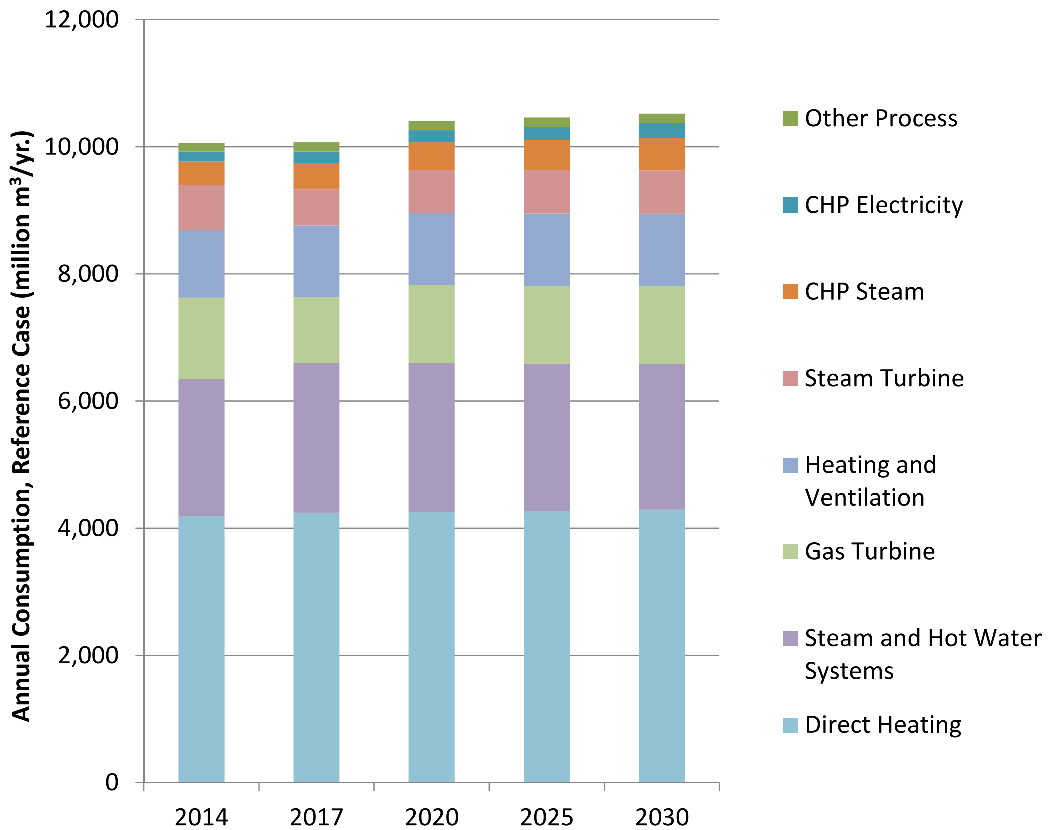


Exhibit 129 Table of Industrial Reference Case Natural Gas Consumption by End Use and Year

Sub-Sector	Consumption (million m^3/yr.)				
	2014	2017	2020	2025	2030
Direct Heating	4,191	4,244	4,255	4,273	4,291
Steam and Hot Water Systems	2,153	2,356	2,341	2,315	2,290
Gas Turbine	1,283	1,031	1,225	1,225	1,225
Heating and Ventilation	1,063	1,130	1,133	1,138	1,142
Steam Turbine	709	570	677	677	677
CHP Steam	371	416	438	476	515
CHP Electricity	153	177	190	211	232
Other Process	137	145	145	146	146
Total	10,060	10,069	10,405	10,461	10,518

6.4 Technical Potential

This section presents estimates of industrial technical potential based on the methodology discussed in section 2.6. Exhibit 130 through Exhibit 135 present the technical potential savings for the industrial sector.

As shown in Exhibit 130 and Exhibit 131, the industrial technical potential savings represent 2,531 million cubic metres or 24% of the reference case natural gas use in 2020, decreasing slightly to 2,474 million cubic metres or 24% by 2030.

Exhibit 130 Graph of Industrial Reference Case and Technical Potential Consumptions

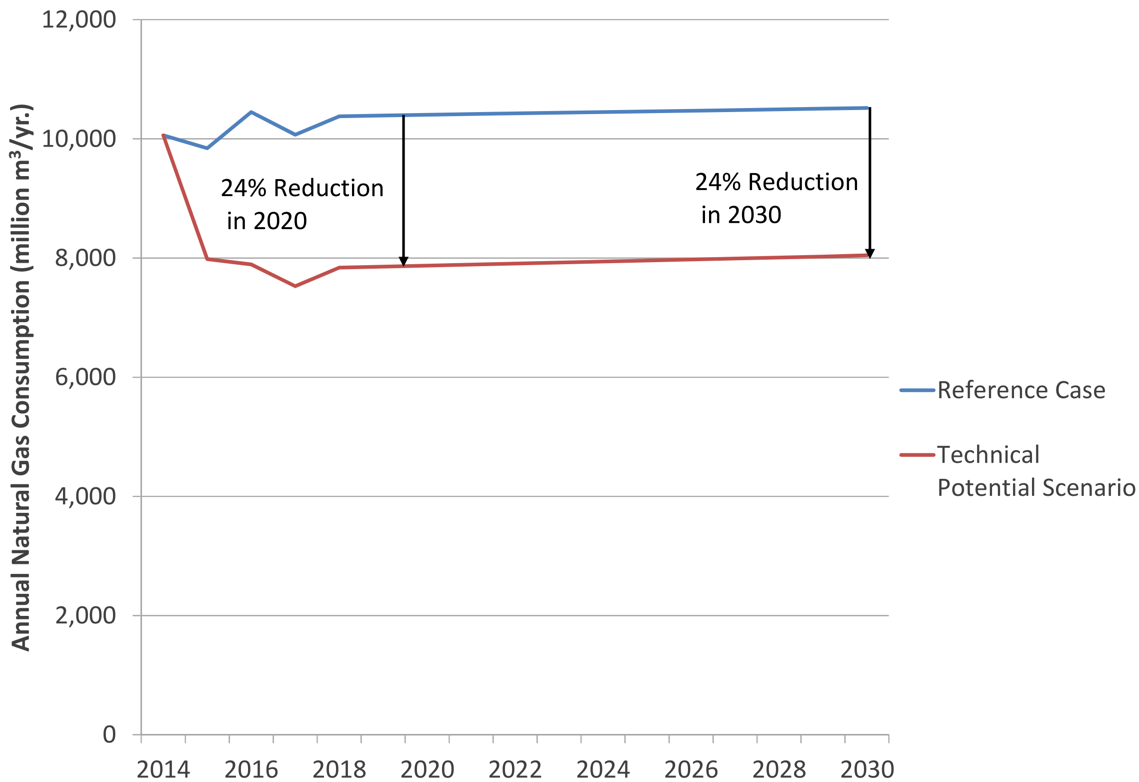


Exhibit 131 Table of Industrial Reference Case and Technical Potential Consumption

Year	Consumption (million m^3/yr.)	
	Reference Case	Technical Potential
2014	10,060	10,060
2015	9,841	7,981
2016	10,450	7,895
2017	10,069	7,525
2018	10,380	7,838
2019	10,394	7,857
2020	10,405	7,874
2025	10,461	7,958
2030	10,518	8,044

As shown in Exhibit 132 and Exhibit 133, in the technical potential scenario for 2020, chemical manufacturing achieves the largest share of industrial savings at 473 million cubic metres or 19%, followed by primary metal manufacturing (397 million cubic metres or 16%), mining, quarrying, and oil and gas extraction (361 million cubic metres or 14%), and miscellaneous manufacturing (31 million cubic metres or 12%). In the technical potential scenario for 2030, the split remains largely the same, with only modest changes in overall savings allocation between sub-sectors.

In the technical potential scenario for 2030, direct heating accounts for 1,296 million cubic metres or 51% of natural gas savings in the industrial sector, followed by steam and hot water systems (598 million cubic metres or 23%), and heating and ventilation (550 million cubic metres or 22%). Similar to the case of the sub-sector allocations of savings between 2020 and 2030, the allocation of savings by end use remain largely the same between 2020 and 2030.

The savings attributions remain largely the same between sub-sectors and end uses between 2020 and 2030 due to the relatively flat natural gas use forecast and the quick ramp-up of measure implementation in the technical potential scenario, which means that all applicable measures are implemented by 2020, with no new opportunities for implementing these measures after 2020.

Exhibit 132 Graph of Industrial Technical Potential Savings by End Use, Year, and Sub-sector

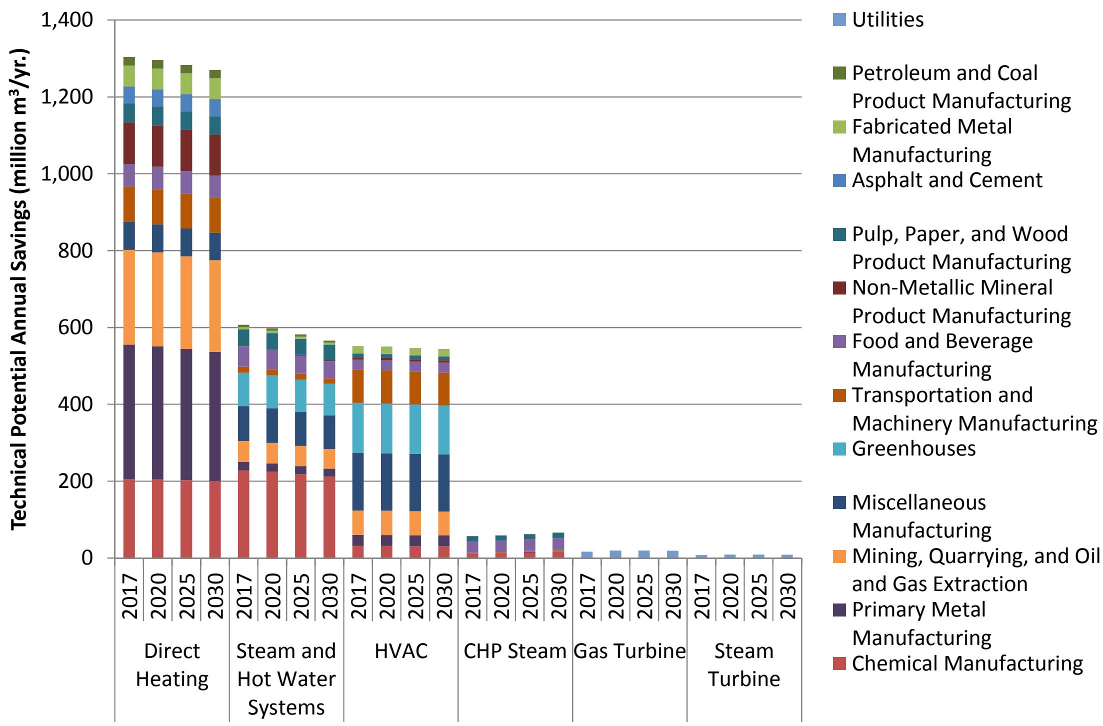


Exhibit 133 Table of Industrial Technical Potential Savings by End Use, Year, and Sub-sector

End Use	Year	Savings (million m^3/yr.)													
		Asphalt and Cement	Chemical Manufacturing	Fabricated Metal Manufacturing	Food and Beverage Manufacturing	Greenhouses	Mining, Quarrying, and Oil and Gas Extraction	Miscellaneous Manufacturing	Non-Metallic Mineral Product Manufacturing	Petroleum and Coal Product Manufacturing	Primary Metal Manufacturing	Pulp, Paper, and Wood Product Manufacturing	Transportation and Machinery Manufacturing	Utilities	Total
Direct Heating	2017	44	206	54	59	-	246	73	107	22	350	50	92	-	1,304
	2020	44	205	54	59	-	244	73	107	22	347	49	92	-	1,296
	2025	44	203	54	58	-	241	72	107	22	341	48	91	-	1,283
	2030	45	200	54	58	-	238	72	107	22	336	48	90	-	1,270
Steam and Hot Water Systems	2017	1	228	5	52	86	54	91	1	7	22	43	16	-	607
	2020	1	224	5	50	85	53	90	1	6	22	43	16	-	598
	2025	1	218	5	47	84	53	88	1	6	21	42	15	-	582
	2030	1	212	5	45	83	52	87	1	5	21	41	14	-	566
Heating and Ventilation	2017	1	31	18	26	131	63	150	6	0	29	10	86	-	552
	2020	1	31	18	26	130	63	149	6	0	29	10	86	-	550
	2025	1	31	18	26	129	62	149	6	0	28	10	85	-	547
	2030	1	31	18	26	128	62	149	6	0	28	9	85	-	544
CHP Steam	2017	0	11	-	29	1	-	0	-	0	0	13	2	-	57
	2020	0	13	-	29	1	-	1	-	0	0	13	2	-	59
	2025	0	14	-	30	1	-	1	-	1	0	13	2	-	63
	2030	0	16	-	31	1	-	2	-	1	0	13	2	-	67
Gas Turbine	2017	-	-	-	-	-	-	-	-	-	-	-	-	17	17
	2020	-	-	-	-	-	-	-	-	-	-	-	-	20	20
	2025	-	-	-	-	-	-	-	-	-	-	-	-	19	19
	2030	-	-	-	-	-	-	-	-	-	-	-	-	19	19
Steam Turbine	2017	-	-	-	-	-	-	-	-	-	-	-	-	8	8
	2020	-	-	-	-	-	-	-	-	-	-	-	-	9	9
	2025	-	-	-	-	-	-	-	-	-	-	-	-	9	9
	2030	-	-	-	-	-	-	-	-	-	-	-	-	9	9
Grand Total	2017	46	477	77	166	217	363	314	115	30	401	116	196	24	2,544
	2020	46	473	77	165	216	361	313	115	29	397	115	195	29	2,531
	2025	46	466	77	162	214	356	311	115	29	391	113	194	28	2,503
	2030	46	459	77	160	212	352	308	115	28	385	111	192	28	2,474

Note: Values in the data table are shown rounded to the nearest million cubic metres

As shown in Exhibit 134 and Exhibit 135, in the technical potential scenario for 2020, large volume Union Gas customers account for 44% of industrial natural gas savings, followed by non-large volume Union Gas customers at 34% and Enbridge Gas Distribution customers at 22%. In the technical potential scenario for 2030, these splits remain largely the same.

Exhibit 134 Graph of Industrial Technical Potential Savings by End Use, Year, and Utility

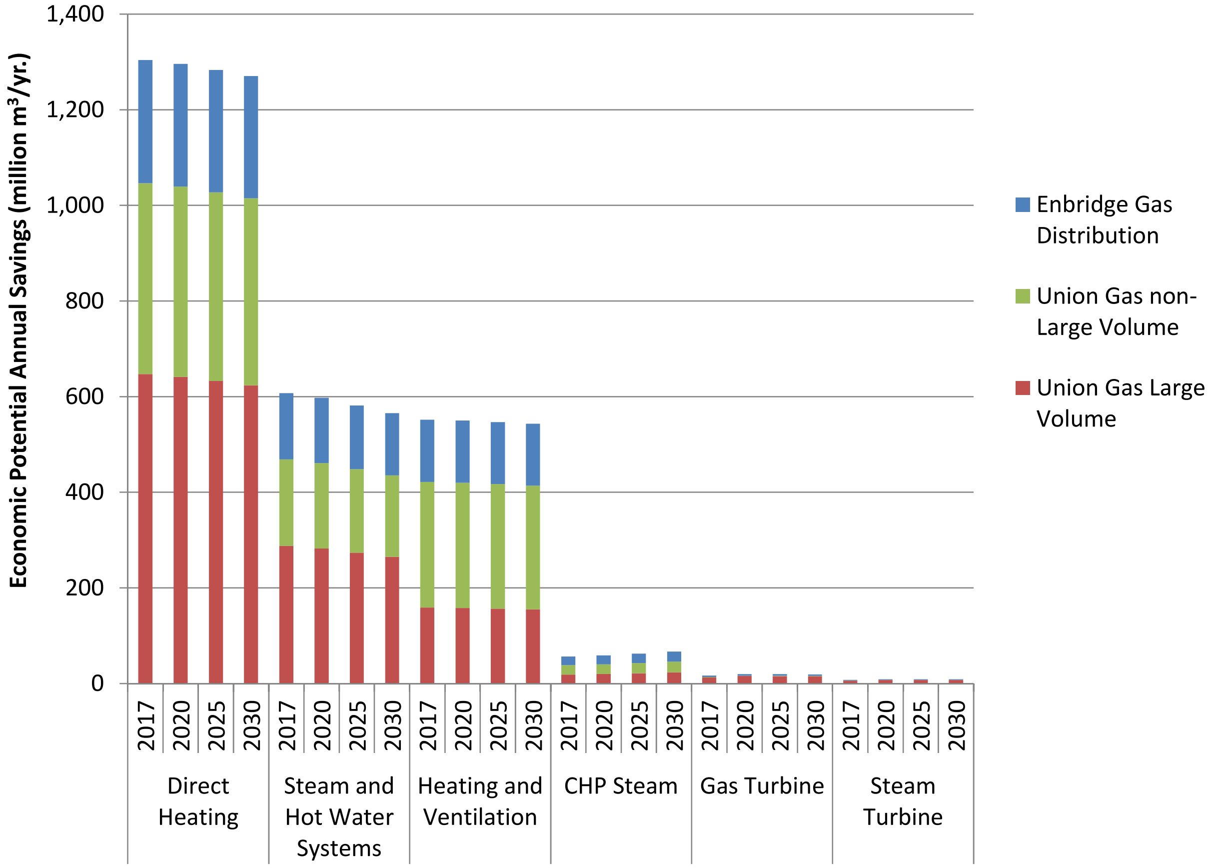


Exhibit 135 Table of Industrial Technical Potential Savings by End Use, Year, and Utility

End Use	Year	Savings (million m^3/yr.)			
		Enbridge Gas Distribution	Union Gas non-Large Volume	Union Gas Large Volume	Total
Direct Heating	2017	258	399	647	1,304
	2020	257	397	642	1,296
	2025	256	394	633	1,283
	2030	255	391	624	1,270
Steam and Hot Water Systems	2017	138	181	288	607
	2020	136	179	282	598
	2025	133	175	274	582
	2030	130	170	265	566
Heating and Ventilation	2017	130	263	159	552
	2020	130	262	158	550
	2025	130	261	156	547
	2030	130	259	155	544
CHP Steam	2017	18	20	19	57
	2020	19	20	20	59
	2025	20	22	21	63
	2030	21	23	23	67
Gas Turbine	2017	3	1	13	17
	2020	3	1	16	20
	2025	3	1	16	19
	2030	3	1	15	19
Steam Turbine	2017	1	0	6	8
	2020	1	0	7	9
	2025	1	0	7	9
	2030	1	0	7	9
Grand Total	2017	548	864	1,131	2,544
	2020	547	860	1,125	2,531
	2025	543	852	1,107	2,503
	2030	540	844	1,089	2,474

6.5 Economic Potential

This section presents estimates of industrial economic potential based on the methodology discussed in section 2.8. Exhibit 136 through Exhibit 141 present the economic potential savings for the industrial sector.

A shown in Exhibit 136 and Exhibit 137, the industrial technical potential savings represent 2,492 million cubic metres or 24% of the reference case in 2020, falling only slightly to 2,438 million cubic metres or 23% in 2030. The economic potential is very close to the technical potential as most of the measures modelled pass the TRC-plus test.

Exhibit 136 Graph of Industrial Reference Case, Technical Potential, and Economic Potential Consumptions

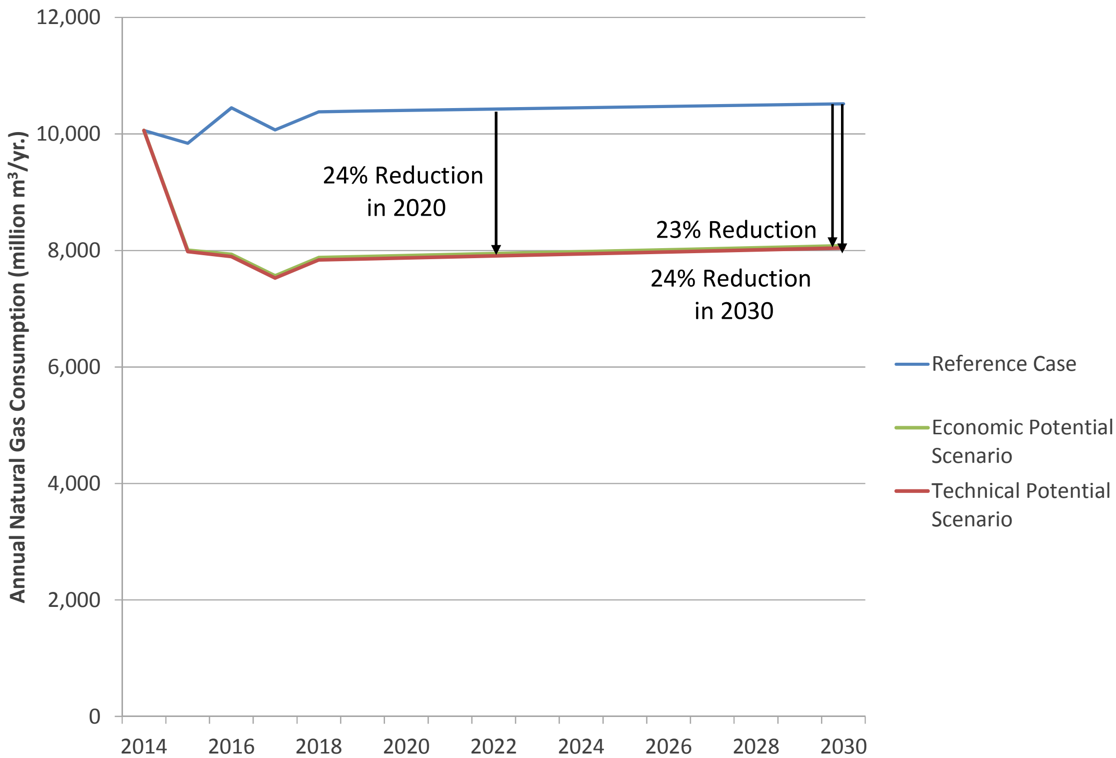


Exhibit 137 Table of Industrial Reference Case, Technical Potential, and Economic Potential Consumptions

Year	Consumption (million m^3/yr.)		
	Reference Case	Technical Potential Scenario	Economic Potential Scenario
2014	10,060	10,060	10,060
2015	9,841	7,981	8,010
2016	10,450	7,895	7,942
2017	10,069	7,525	7,573
2018	10,380	7,838	7,885
2019	10,394	7,857	7,904
2020	10,405	7,874	7,920
2025	10,461	7,958	8,005
2030	10,518	8,044	8,083

As shown in Exhibit 138 and Exhibit 139, similar to the technical potential scenario results, in the economic potential scenario for 2020, chemical manufacturing achieves the largest share of industrial savings at 467 million cubic metres or 19%, followed by primary metal manufacturing (395 million cubic metres or 16%), mining (345 million cubic metres or 14%), and miscellaneous manufacturing (310 million cubic metres or 13%). These results remain largely the same in 2030.

Exhibit 138 Graph of Industrial Economic Potential Savings by End Use, Year, and Sub-sector

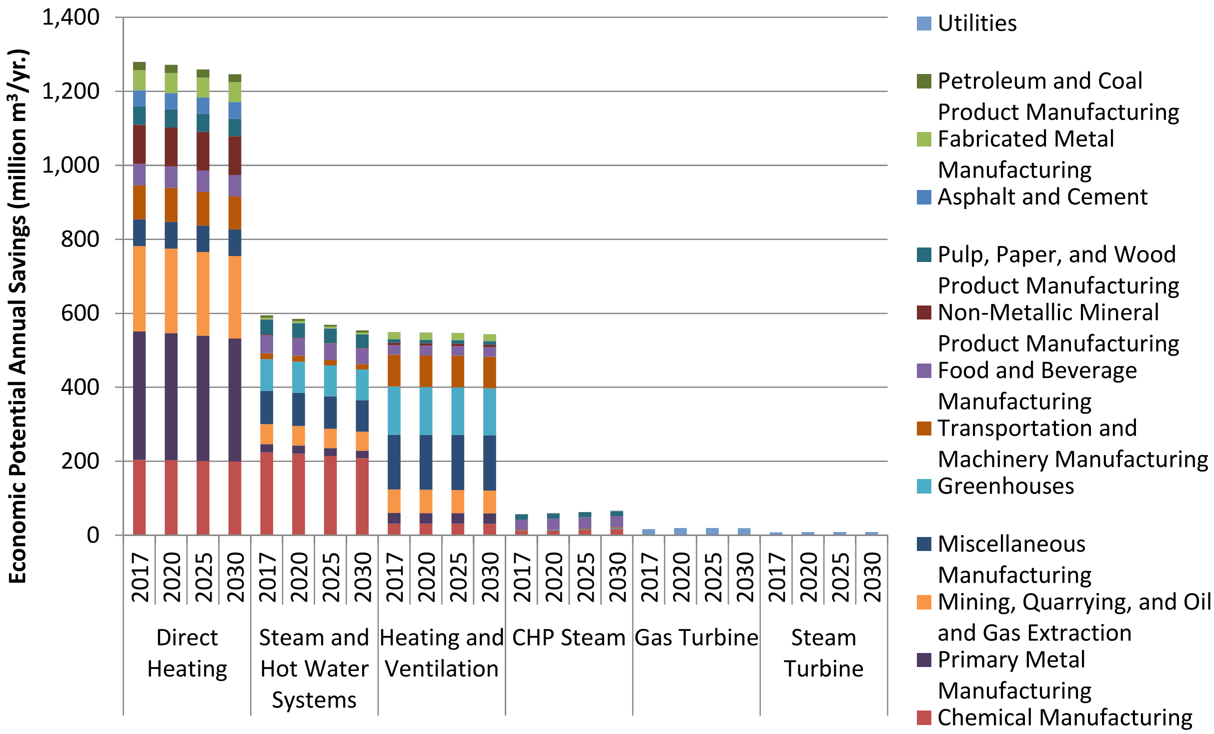


Exhibit 139 Table of Industrial Economic Potential Savings by End Use, Year, and Sub-sector

End Use	Year	Savings (million m^3/yr.)													
		Asphalt and Cement	Chemical Manufacturing	Fabricated Metal Manufacturing	Food and Beverage Manufacturing	Greenhouses	Mining, Quarrying, and Oil and Gas Extraction	Miscellaneous Manufacturing	Non-Metallic Mineral Product Manufacturing	Petroleum and Coal Product Manufacturing	Primary Metal Manufacturing	Pulp, Paper, and Wood Product Manufacturing	Transportation and Machinery Manufacturing	Utilities	Total
Direct Heating	2017	44	204	54	58	-	230	73	105	22	347	49	92	-	1,279
	2020	44	203	54	58	-	229	72	105	22	344	49	91	-	1,272
	2025	44	201	54	58	-	226	72	105	22	339	48	91	-	1,259
	2030	45	199	54	58	-	223	71	105	22	333	47	90	-	1,246
Steam and Hot Water Systems	2017	1	224	5	48	86	54	90	1	7	22	40	16	-	595
	2020	1	220	5	47	85	53	89	1	6	22	39	16	-	585
	2025	1	214	5	44	84	53	87	1	6	21	38	15	-	569
	2030	1	208	5	41	82	52	85	1	5	21	38	14	-	554
Heating and Ventilation	2017	1	31	18	26	131	63	148	6	0	29	10	85	-	549
	2020	1	31	18	26	130	63	148	6	0	29	10	85	-	547
	2025	1	31	18	26	129	62	149	6	0	28	10	85	-	547
	2030	1	31	18	26	128	62	149	6	0	28	9	85	-	544
CHP Steam	2017	0	11	-	29	1	-	0	-	0	0	13	2	-	57
	2020	0	13	-	29	1	-	1	-	0	0	13	2	-	59
	2025	0	14	-	30	1	-	1	-	1	0	13	2	-	63
	2030	0	16	-	31	1	-	2	-	1	0	13	2	-	67
Gas Turbine	2017	-	-	-	-	-	-	-	-	-	-	-	-	17	17
	2020	-	-	-	-	-	-	-	-	-	-	-	-	20	20
	2025	-	-	-	-	-	-	-	-	-	-	-	-	19	19
	2030	-	-	-	-	-	-	-	-	-	-	-	-	19	19
Steam Turbine	2017	-	-	-	-	-	-	-	-	-	-	-	-	8	8
	2020	-	-	-	-	-	-	-	-	-	-	-	-	9	9
	2025	-	-	-	-	-	-	-	-	-	-	-	-	9	9
	2030	-	-	-	-	-	-	-	-	-	-	-	-	9	9
Grand Total	2017	46	471	77	162	217	348	311	113	30	398	113	195	24	2,504
	2020	46	467	77	161	216	345	310	113	29	395	111	194	29	2,492
	2025	46	460	77	159	213	341	309	113	29	389	109	193	28	2,466
	2030	46	454	77	156	211	336	306	113	28	382	108	192	28	2,438

Note: Values in the data table are shown rounded to the nearest million cubic metres

As shown in Exhibit 140 and Exhibit 141, similar to the technical potential results, in the economic potential scenario for 2030, large volume Union Gas customers account for 44% of industrial natural gas savings, followed by non-large volume Union Gas customers at 34% and Enbridge Gas Distribution customers at 22%.

Exhibit 140 Graph of Industrial Economic Potential Savings by End Use, Year, and Utility

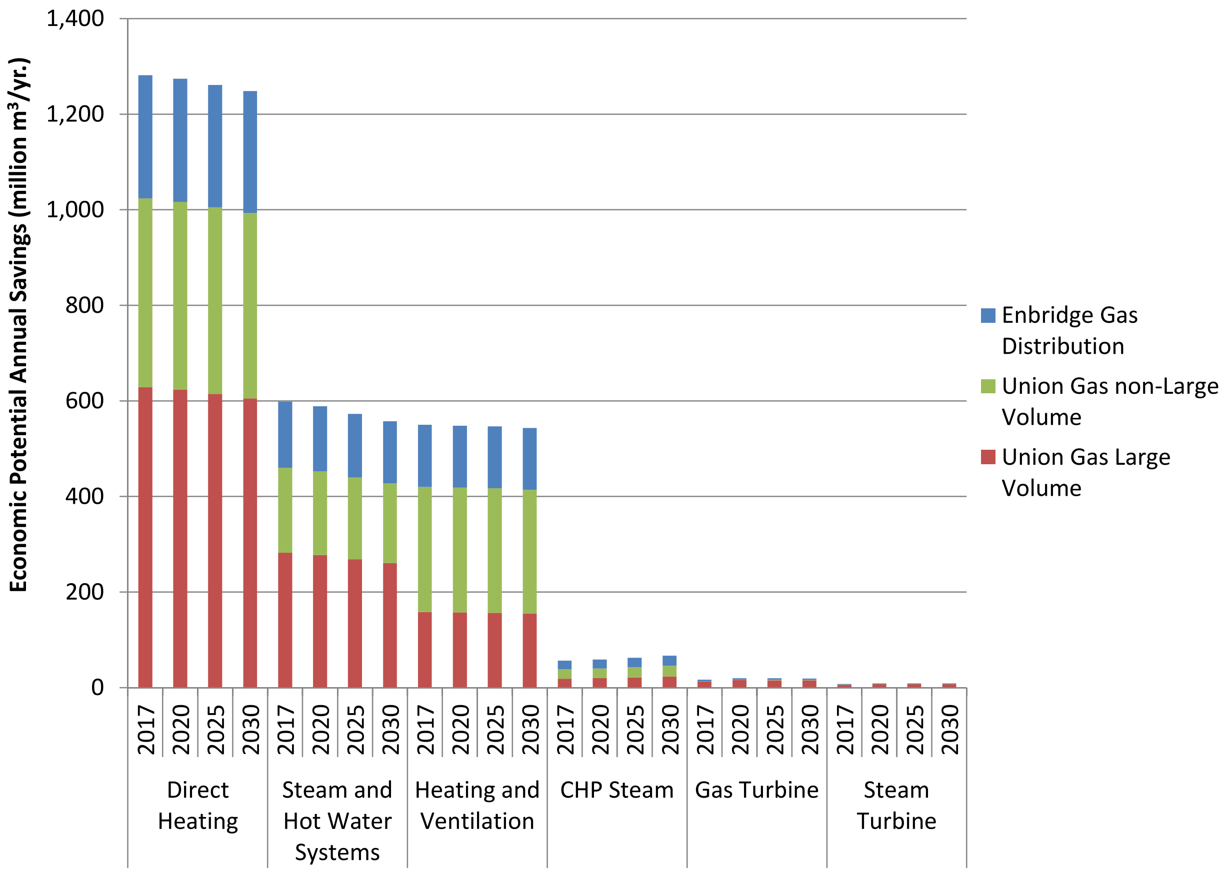


Exhibit 141 Table of Industrial Economic Potential Savings by End Use, Year, and Utility

End Use	Year	Savings (million m³/yr.)			
		Enbridge Gas Distribution	Union Gas non-Large Volume	Union Gas Large Volume	Total
Direct Heating	2017	255	395	629	1,279
	2020	255	394	623	1,272
	2025	254	391	614	1,259
	2030	253	388	606	1,246
Steam and Hot Water Systems	2017	134	178	283	595
	2020	133	175	277	585
	2025	130	171	269	569
	2030	126	167	260	554
Heating and Ventilation	2017	129	262	158	549
	2020	129	261	157	547
	2025	130	261	156	547
	2030	130	259	155	544
CHP Steam	2017	18	20	19	57
	2020	19	20	20	59
	2025	20	22	21	63
	2030	21	23	23	67
Gas Turbine	2017	3	1	13	17
	2020	3	1	16	20
	2025	3	1	16	19
	2030	3	1	15	19
Steam Turbine	2017	1	0	6	8
	2020	1	0	7	9
	2025	1	0	7	9
	2030	1	0	7	9
Grand Total	2017	541	856	1,107	2,504
	2020	540	851	1,101	2,492
	2025	538	845	1,084	2,466
	2030	534	837	1,066	2,438

6.6 Achievable Potential

This section presents estimates of industrial achievable potential based on the methodology discussed in section 2.8.

6.6.1 Summary of Industrial Sector Achievable Potential Interviews

Seven industrial interviews were conducted in order to collect information for the achievable potential scenarios. The following measure categories as primary topics (in each case, other related measures were discussed at the end):

- Energy management
- Exhaust gas heat recovery
- Improved building envelope
- Condensing economizers
- High Efficiency Burners

Interviewees were asked to focus on one target sub-sector, based on whichever one they were most familiar with and were comfortable discussing, and later to discuss as many of the other sub-sectors as they were able to and compare them to the main sub-sector that was discussed.

6.6.2 Industrial Specific Assumptions

For measures considered at BAU program levels, incentives were based on the rates (dollars per cubic metre) that the utilities currently offer in their industrial DSM programs, along with the associated caps on incentive levels. For aggressive program measures, incentives were calculated in order to reduce the customer payback to 1 year. This level of incentive is considered a strong driver for measure adoption, based on the consultations, input from the utilities, and ICF's experience. For BAU program levels, the ratio of non-incentive to incentive costs was set at 0.5, based on ICF's experience. For the aggressive programs, where incentive costs were significantly higher, a ratio of 0.2 was used, to reflect the proportionally lower overhead costs associated with higher cash incentives, which is also based on ICF's experience.

6.6.3 Program Cost Supply Curves

This section presents the program supply curves for the non-large volume and large volume industrial sector.

As shown in Exhibit 142, the program costs in the unconstrained scenario for the non-large volume industrial sector reach $687 million, with only marginal increases in lifetime savings over the semi-constrained achievable scenario of 452 million cubic metres.

Conversely, as shown in Exhibit 145, although the program costs in the unconstrained scenario for the large volume industrial sector reach $442 million the associated savings are fairly significant and increase by 1,725 million cubic metres above the natural gas savings in the semi-constrained scenario.

As indicated in Exhibit 142 by the horizontal threshold lines, the constrained and semi-constrained budgets with overhead for non-large volume industry were $113 million and $155 million, respectively, for the period 2015-2020. The modelled constrained and semi-constrained budgets for the period 2015-2020 were $111 million and $153 million, due to model optimization restrictions.

The constrained and semi-constrained budgets with overhead for non-large volume industry were $207 million and $413 million, respectively, for the period 2021-2020, which are the same as the modelled budgets.

As shown in Exhibit 142 and Exhibit 143, the non-large volume unconstrained total spending up to 2020 was estimated to be $687 million with associated savings of 7,602 million cubic metres of natural gas. In comparison, the semi-constrained budget represents 23% of the unconstrained budget and saves 7,170 million cubic metres of natural gas, or about 94% of the unconstrained savings.

Similarly, the constrained scenario budget represents 16% of the unconstrained budget and saves 6,564 million cubic metres of natural gas, or 86% of the unconstrained savings.

For both the non-large volume industrial semi-constrained and constrained scenarios, the average program spending up to 2020 is about $0.02 per lifetime cubic metre of natural gas saved, while for the unconstrained scenario it is $0.09 per lifetime cubic metre of natural gas saved. These results show significant diminishing returns for increased spending on the measures modelled in this study.

Exhibit 142 Graph of Industrial Supply Curves: Non-Large volume Program Costs to 2020

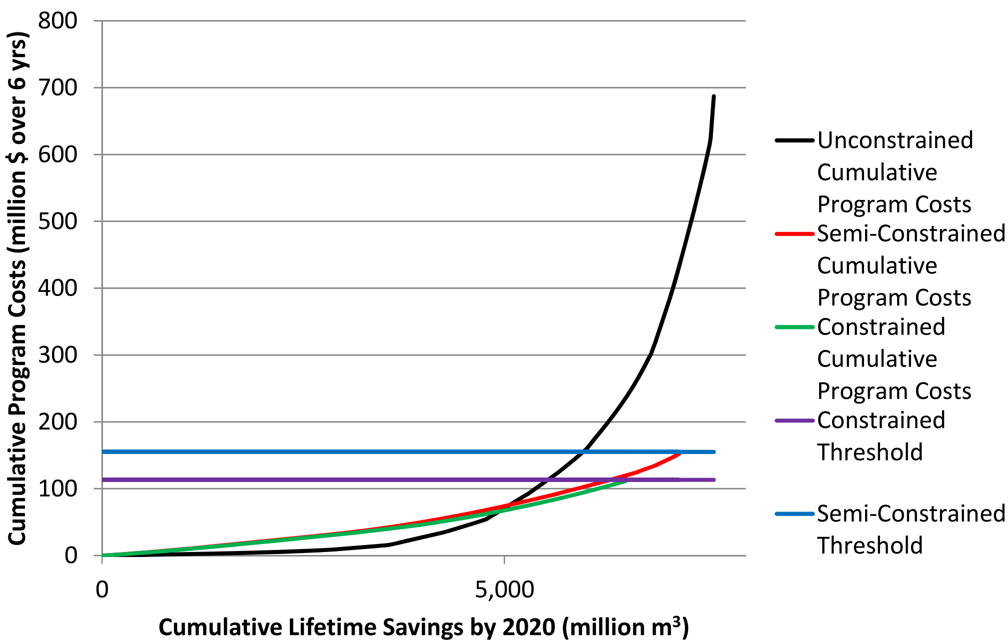


Exhibit 143 Table of Non-Large volume Industrial Achievable Potential Savings and Program Cost Results[74]

Value	Unconstrained		Semi-Constrained		Constrained	
	Year					
	2020	2030	2020	2030	2020	2030
Annual Savings (million m^3/yr.)	460	1,073	433	1,008	398	813
Measure Lifecycle Savings (million m^3)	7,602	18,639	7,170	17,379	6,564	14,393
Value of Savings (million $)	7,950	49,826	7,498	46,457	6,864	38,475
Program Spending to Milestone Year (million $)	687*	3,186*	153	566	113	320
Average Annual Program Spending (million $/yr.)	115*	199*	26	35	19	20
Average Program Spending up to Milestone Year ($/$m^3$)	0.09*	0.17*	0.02	0.03	0.02	0.02

**Note: These are not specific program costs but are the total costs for the scenario.*

[74] See footnote 64 for details on the values in this table.

As is indicated in Exhibit 144 by the horizontal threshold lines, the constrained and semi-constrained budgets with overhead for large volume industry were $24 million and $34 million, respectively, for the period 2015-2020. The modelled constrained and semi-constrained budgets for the period 2015-2020 were $26 million and $33 million, due to model optimization restrictions.

The constrained and semi-constrained budgets with overhead for large volume industry were $43 million and $86 million, respectively, for the period 2021-2020. The modelled constrained and semi-constrained budgets for the period 2015-2020 were $39 million and $77 million, due to model optimization restrictions.

As shown in Exhibit 144 and Exhibit 145, the large volume unconstrained total spending up to 2020 was estimated to be $442 million with associated savings of 5,726 million cubic metres of natural gas. In comparison, the semi-constrained budget represents 7.5% of the unconstrained budget and saves 241 million cubic metres of natural gas, or about 69% of the unconstrained savings. Similarly, the constrained scenario budget represents 6% of the unconstrained budget and saves 183 million cubic metres of natural gas, or 53% of the unconstrained savings.

For both the large volume industrial semi-constrained and constrained scenarios, the average program spending up to 2020 is about $0.02 per lifetime cubic metre of natural gas saved, while for the unconstrained scenario it is $0.09 per lifetime cubic metre of natural gas saved. These results show significant diminishing returns for increased spending on the measures modelled in this study.

Exhibit 144 Graph of Industrial Supply Curves: Large volume Program Costs to 2020

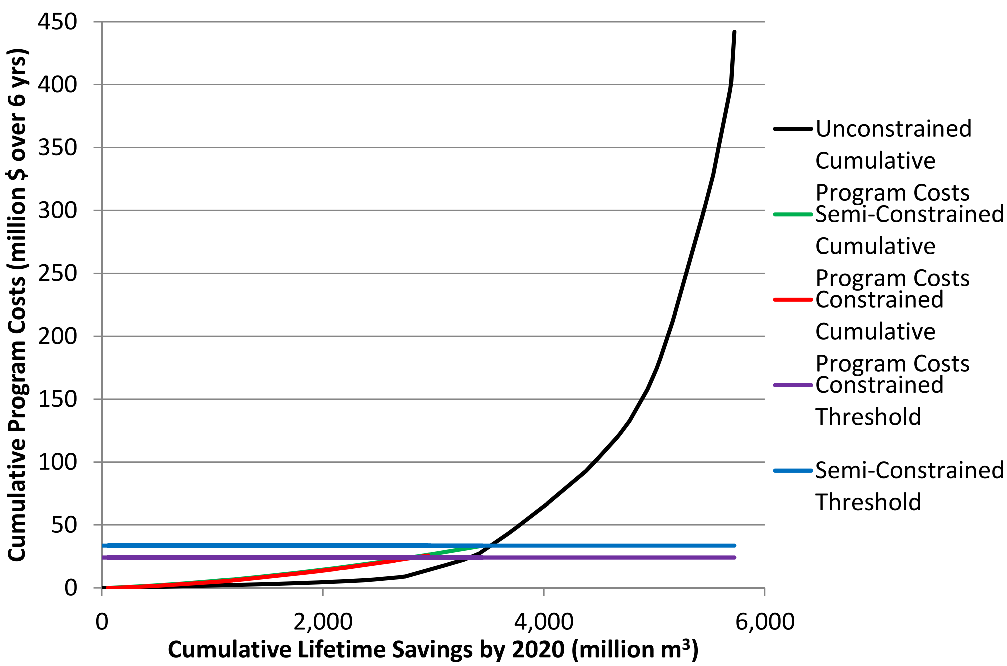


Exhibit 145 Table of Large Volume Industrial Achievable Potential Savings and Program Cost Results[75]

Value	Unconstrained		Semi-Constrained		Constrained	
	Year					
	2020	2030	2020	2030	2020	2030
Annual Savings (million m^3/yr.)	350	801	241	560	183	368
Measure Lifecycle Savings (million m^3)	5,726	14,238	3,999	10,090	1,174	6,313
Value of Savings (million $)	5,988	38,060	4,182	26,972	1,228	16,876
Program Spending to Milestone Year (million $)	442*	2,158*	33	110	26	65
Average Annual Program Spending (million $/yr.)	74*	135*	6	7	4	4
Average Program Spending up to Milestone Year ($/m^3)	0.08*	0.15*	0.01	0.01	0.02	0.01

**Note: These are not specific program costs but are the total costs for the scenario.*

[75] See footnote 64 for details on the values in this table.

6.6.4 Achievable Potential Summary – All Scenarios

As shown in Exhibit 146 and Exhibit 147, the unconstrained, semi-constrained, and constrained achievable potential scenarios could potentially reduce industrial consumption by 7.8%, 6.5%, and 5.6%, respectively, relative to industrial reference case consumption, by 2020, and by 17.8%, 14.9%, and 11.2%, respectively, relative to the industrial reference case consumption, by 2030. This large increase in potential savings between 2020 and 2030 is indicative of the ramp up rates that are typical of industrial project, which often require long lead times.

Exhibit 146 Graph of Industrial Reference, Technical Potential, Economic Potential, and Achievable Potential Annual Consumption by Year

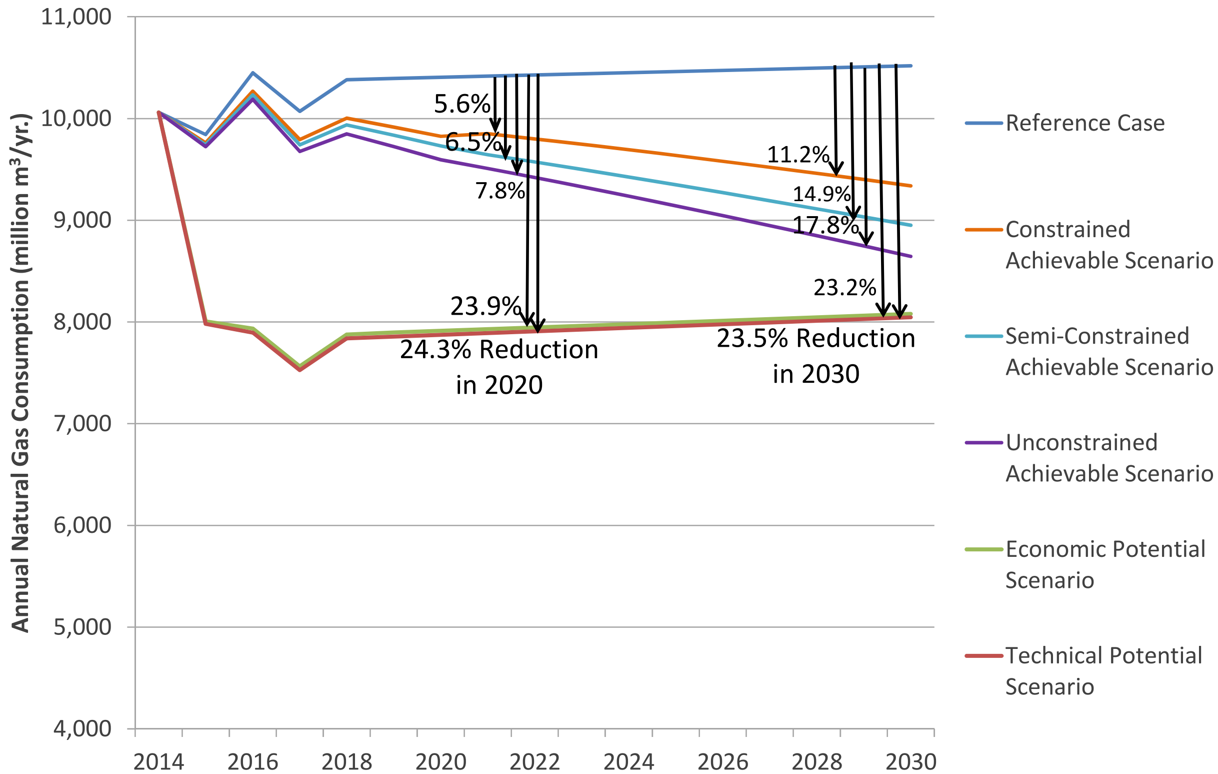


Exhibit 147 Table of Industrial Reference, Technical Potential, Economic Potential, and Achievable Potential Annual Savings Relative to Reference Case

Year	Reference Case Use (million m^3/yr.)	Technical Potential		Economic Potential		Unconstrained Achievable Potential		Semi-constrained Achievable Potential		Constrained Achievable Potential	
		Absolute Savings (million m^3/yr.)	Savings Relative to Reference Case (%)	Absolute Savings (million m^3/yr.)	Relative to Reference Case (%)	Absolute Savings (million m^3/yr.)	Relative to Reference Case (%)	Absolute Savings (million m^3/yr.)	Relative to Reference Case (%)	Absolute Savings (million m^3/yr.)	Relative to Reference Case (%)
2015	9,841	1,861	18.9%	1,835	18.6%	118	1.2%	100	1.0%	82	0.8%
2016	10,450	2,555	24.5%	2,515	24.1%	260	2.5%	218	2.1%	181	1.7%
2017	10,069	2,544	25.3%	2,504	24.9%	393	3.9%	328	3.3%	276	2.7%
2018	10,380	2,542	24.5%	2,502	24.1%	532	5.1%	443	4.3%	376	3.6%
2019	10,394	2,537	24.4%	2,497	24.0%	670	6.5%	558	5.4%	478	4.6%
2020	10,405	2,531	24.3%	2,492	23.9%	810	7.8%	674	6.5%	581	5.6%
2025	10,461	2,503	23.9%	2,466	23.6%	1,320	12.6%	1,113	10.6%	825	7.9%
2030	10,518	2,474	23.5%	2,438	23.2%	1,874	17.8%	1,569	14.9%	1,181	11.2%

6.6.5 Achievable Potential – Unconstrained Scenario

As was shown in Exhibit 147 the total unconstrained achievable potential scenario in the industrial sector results in natural savings of 810 million cubic metres by 2020, or 7.8% of 2020 industrial reference case consumption, and 1,874 million cubic metres by 2030, or 17.8% of 2030 industrial reference case consumption. The remainder of this section provides a breakdown of the industrial unconstrained achievable potential results

As shown in Exhibit 148 and Exhibit 149, in 2020, the direct heating end use accounts for 392 million cubic metres or 48% of natural gas savings in the industrial sector, followed by heating and ventilation (201 million cubic metres or 25%), and steam and hot water systems (168 million cubic metres or 21%). Similarly, in 2030, the direct heating end use accounts for 49% (915 million cubic metres) of natural gas savings in the industrial sector, followed by heating and ventilation (453 million cubic metres or 24%), and steam and hot water systems (422 million cubic metres or 22%).

In 2020, the chemical manufacturing sub-sector is expected to achieve the largest share of industrial savings at 144 million cubic metres or 18%, followed mining, quarrying, and oil and gas extraction (107 million cubic metres or 13%), primary metal manufacturing (104 million cubic metres or 13%), and miscellaneous manufacturing (99 million cubic metres or 12%). Similarly, in 2030, the chemical manufacturing sub-sector achieves the largest share of industrial savings at 345 million cubic metres or 18%, followed by primary metal manufacturing (263 million cubic metres or 14%), mining, quarrying, and oil and gas extraction (246 million cubic metres or 13%), and miscellaneous manufacturing (246 million cubic metres or 13%).

Exhibit 148 Graph of Industrial Unconstrained Achievable Potential Savings by End Use, Year, and Sub-Sector

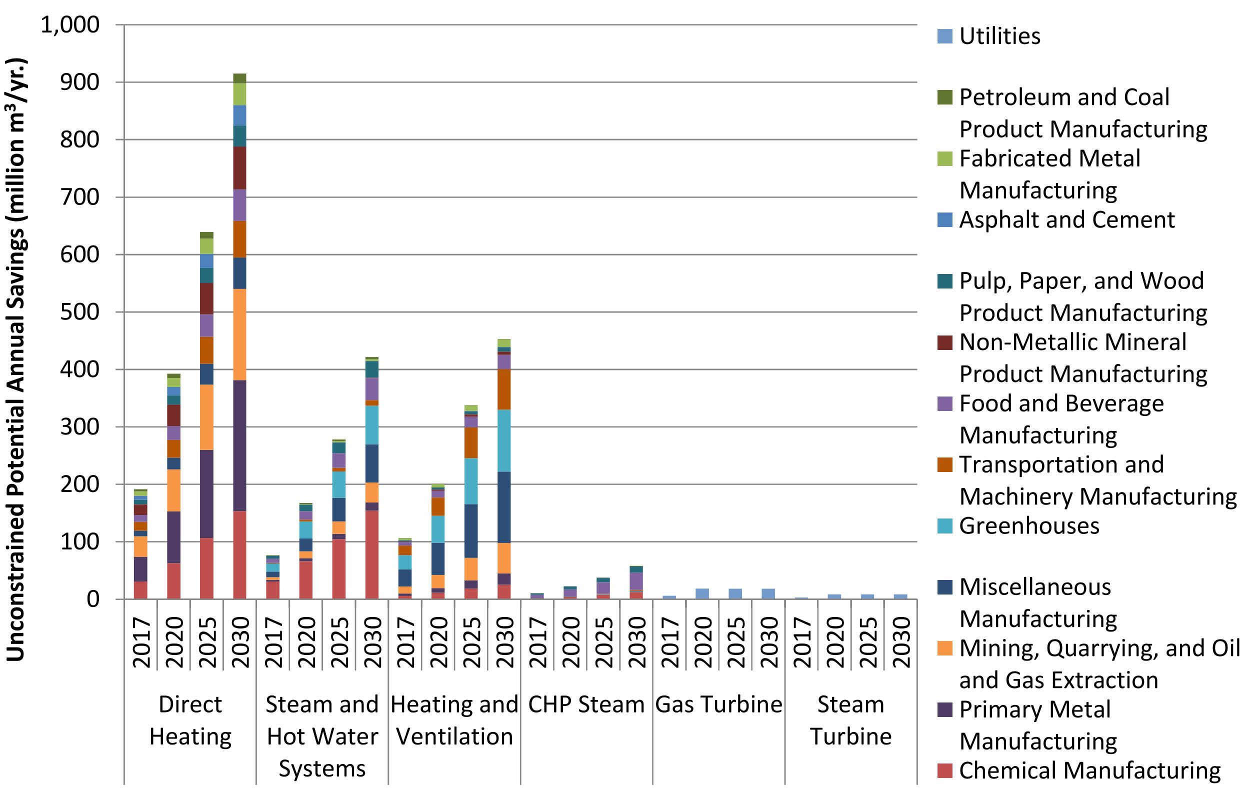


Exhibit 149 Table of Industrial Unconstrained Achievable Potential Savings by End Use, Year, and Sub-Sector

End Use	Year	Savings (million m³/yr.)													
		Asphalt and Cement	Chemical Manufacturing	Fabricated Metal Manufacturing	Food and Beverage Manufacturing	Greenhouses	Mining, Quarrying, and Oil and Gas Extraction	Miscellaneous Manufacturing	Non-Metallic Mineral Product Manufacturing	Petroleum and Coal Product Manufacturing	Primary Metal Manufacturing	Pulp, Paper, and Wood Product Manufacturing	Transportation and Machinery Manufacturing	Utilities	Total
Direct Heating	2017	7	31	8	12	-	36	10	18	4	43	8	15	-	191
	2020	15	63	16	25	-	73	20	37	7	90	16	31	-	392
	2025	24	106	26	39	-	114	36	55	12	154	26	47	-	639
	2030	35	153	38	55	-	159	54	74	17	228	37	64	-	915
Steam and Hot Water Systems	2017	0	31	0	7	14	5	10	0	1	3	5	1	-	77
	2020	0	66	1	14	30	12	22	0	2	6	11	3	-	168
	2025	0	105	2	25	46	21	41	1	3	9	19	6	-	278
	2030	1	154	3	38	67	35	66	1	4	14	29	10	-	422
Heating and Ventilation	2017	0	6	3	6	25	12	30	1	0	4	2	17	-	106
	2020	0	11	6	11	47	23	56	2	0	8	3	32	-	201
	2025	0	19	10	19	80	39	94	4	0	14	6	53	-	338
	2030	0	25	14	25	108	53	124	5	0	20	7	71	-	453
CHP Steam	2017	0	2	-	6	0	-	0	-	0	0	2	0	-	10
	2020	0	4	-	12	0	-	0	-	0	0	5	0	-	22
	2025	0	7	-	20	0	-	1	-	0	0	7	1	-	38
	2030	0	12	-	30	1	-	1	-	1	0	11	1	-	58
Gas Turbine	2017	-	-	-	-	-	-	-	-	-	-	-	-	6	6
	2020	-	-	-	-	-	-	-	-	-	-	-	-	19	19
	2025	-	-	-	-	-	-	-	-	-	-	-	-	18	18
	2030	-	-	-	-	-	-	-	-	-	-	-	-	18	18
Steam Turbine	2017	-	-	-	-	-	-	-	-	-	-	-	-	3	3
	2020	-	-	-	-	-	-	-	-	-	-	-	-	9	9
	2025	-	-	-	-	-	-	-	-	-	-	-	-	9	9
	2030	-	-	-	-	-	-	-	-	-	-	-	-	8	8
Grand Total	2017	7	69	11	30	39	53	49	20	5	50	17	34	9	393
	2020	15	144	22	62	77	107	99	40	10	104	35	67	27	810
	2025	25	237	38	103	126	174	172	59	15	177	58	107	27	1,320
	2030	36	345	55	148	176	246	246	81	22	263	84	146	27	1,874

Savings are rounded to the nearest million cubic metre. The value of “0” does not necessarily mean there are no savings.

As shown in Exhibit 150 and Exhibit 151, in 2020, large volume Union Gas customers are expected to account for 350 million cubic metres or 43% of industrial natural gas savings, followed by non-large volume Union Gas customers at 281 million cubic metres or 35% and Enbridge Gas Distribution customers at 179 million cubic metres or 22%. These proportions remain the same in 2030, with large volume Union Gas consumption increasing to 801 million cubic metres, non-large volume Union Gas consumption increasing to 653 million cubic metres and Enbridge Gas Distribution consumption increasing to 420 million cubic metres of natural gas.

Exhibit 150 Graph of Industrial Unconstrained Achievable Potential Savings by End Use, Year, and Utility

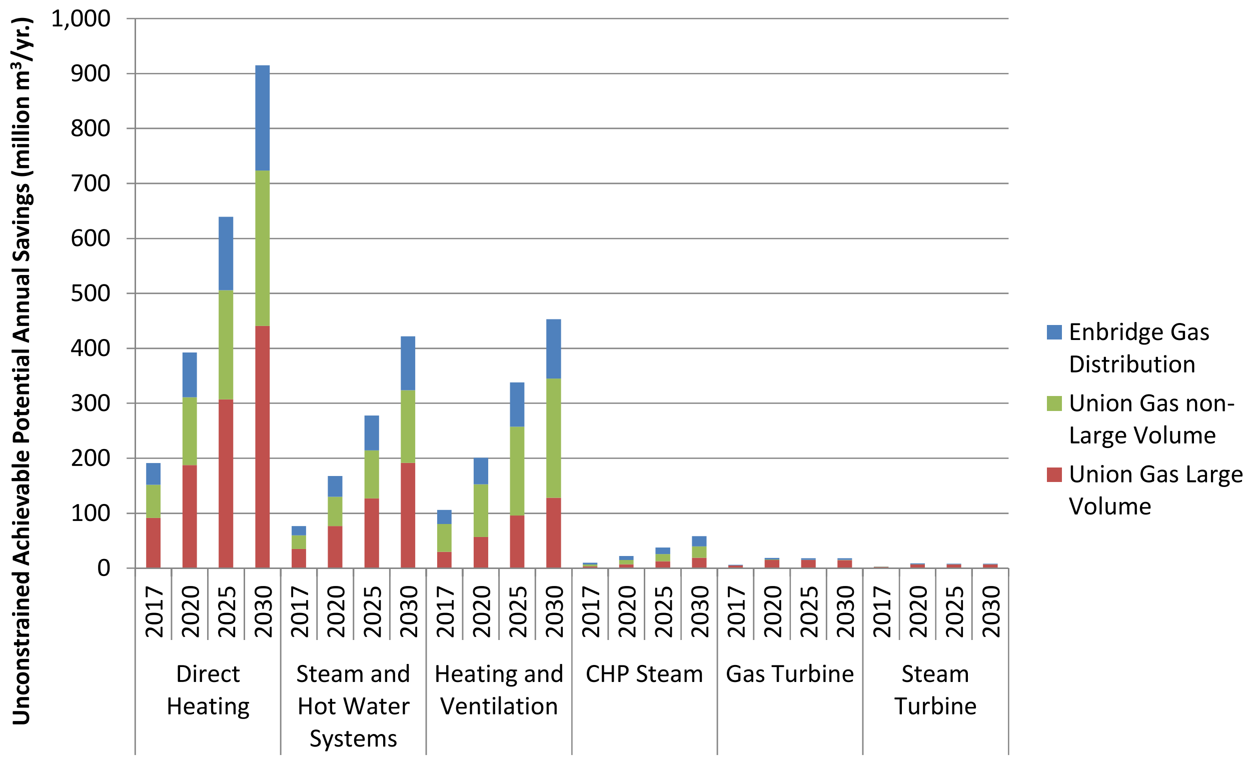


Exhibit 151 Table of Industrial Unconstrained Achievable Potential Savings by End Use, Year, and Utility

End Use	Milestone Years	Enbridge Gas Distribution	Union Gas non-Large Volume	Union Gas Large Volume	Total
Direct Heating	2017	40	60	92	191
	2020	82	123	188	392
	2025	134	198	307	639
	2030	192	283	441	915
Steam and Hot Water Systems	2017	17	25	35	77
	2020	38	53	77	168
	2025	64	88	127	278
	2030	98	132	192	422
Heating and Ventilation	2017	25	51	30	106
	2020	48	96	57	201
	2025	81	161	96	338
	2030	108	217	128	453
CHP Steam	2017	3	4	3	10
	2020	7	8	7	22
	2025	12	13	12	38
	2030	19	20	19	58
Gas Turbine	2017	1	0	5	6
	2020	3	1	15	19
	2025	3	1	15	18
	2030	3	1	15	18
Steam Turbine	2017	1	0	2	3
	2020	1	0	7	9
	2025	1	0	7	9
	2030	1	0	7	8
Grand Total	2017	87	139	167	393
	2020	179	281	350	810
	2025	295	462	564	1,320
	2030	420	653	801	1,874

Savings are rounded to the nearest million cubic metre. The value of “0” does not necessarily mean there are no savings.

6.6.6 Achievable Potential – Semi-constrained Scenario

As was shown in Exhibit 147, the total semi-constrained achievable potential scenario in the industrial sector results in natural savings of 674 million cubic metres by 2020, or 6.5% of 2020 industrial reference case consumption, and 1,569 million cubic metres by 2030, or 14.9% of 2030 industrial reference case consumption. The remainder of this section provides a breakdown of the industrial semi-constrained achievable potential results

As shown in Exhibit 152 and Exhibit 153 in 2020, the direct heating end use accounts for 347 million cubic metres or 51% of semi-constrained achievable natural gas savings in the industrial sector, followed by heating and ventilation (161 million cubic metres or 24%), and steam and hot water systems (127 million cubic metres or 19%). Similarly, in 2030, the direct heating end use accounts for 51% (799 million cubic metres) of semi-constrained achievable natural gas savings, followed by heating and ventilation (372 million cubic metres or 24%), and steam and hot water systems (332 million cubic metres or 21%), which increased in potential savings slightly more than other end-uses.

In 2020, the chemical manufacturing sub-sector is expected to achieve the largest share of semi-constrained achievable industrial savings at 107 million cubic metres or 16%, followed by primary metal manufacturing (87 million cubic metres or 13%), mining, quarrying, and oil and gas extraction (74 million cubic metres or 11%), and miscellaneous manufacturing (81 million cubic metres or 12%). Similarly, in 2030, the chemical manufacturing sub-sector is expected to achieve the largest share of semi-constrained achievable industrial savings at 266 million cubic metres or 17%, followed by primary metal manufacturing (217 million cubic metres or 14%), mining, quarrying, and oil and gas extraction (172 million cubic metres or 11%), and miscellaneous manufacturing (204 million cubic metres or 13%).

Exhibit 152 Graph of Industrial Semi-Constrained Achievable Potential Savings by End Use, Year, and Sub-Sector

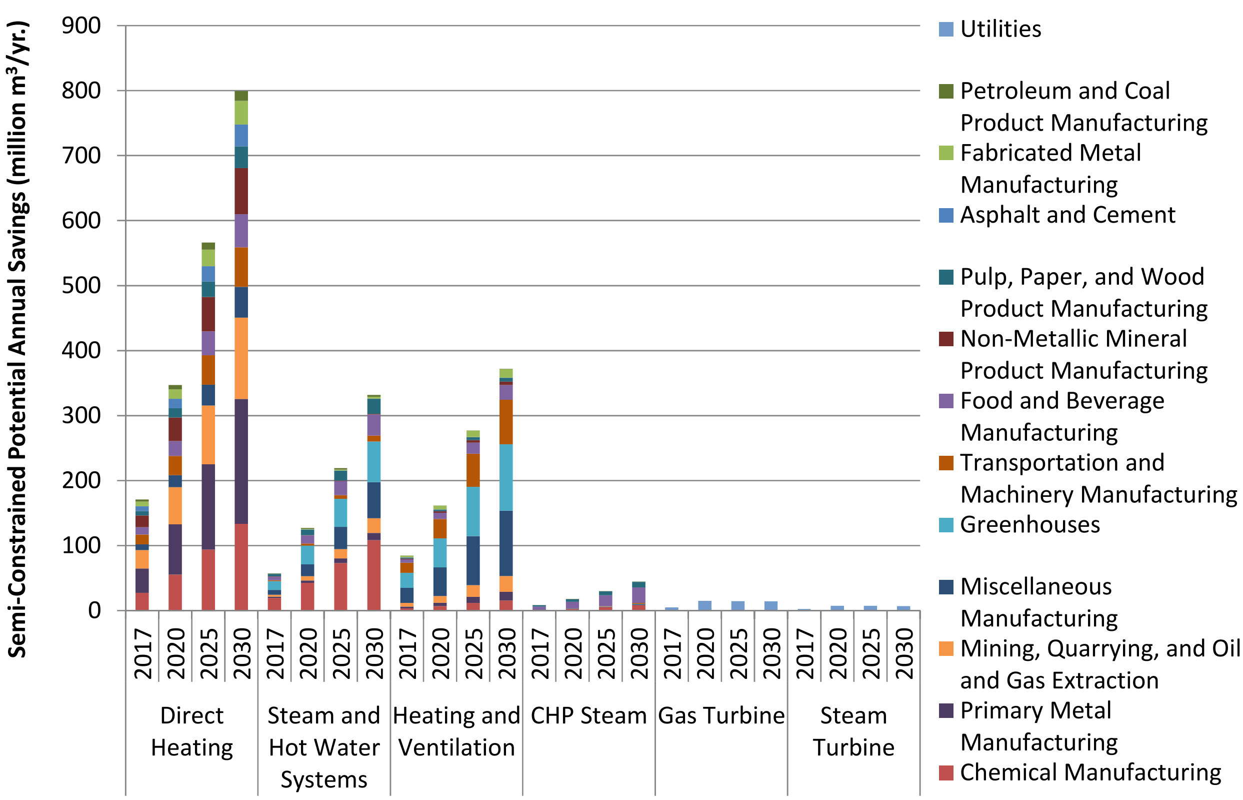


Exhibit 153 Table of Industrial Semi-Constrained Achievable Potential Savings by End Use, Year, and Sub-Sector

End Use	Year	Savings (million m^3/yr.)													
		Asphalt and Cement	Chemical Manufacturing	Fabricated Metal Manufacturing	Food and Beverage Manufacturing	Greenhouses	Mining, Quarrying, and Oil and Gas Extraction	Miscellaneous Manufacturing	Non-Metallic Mineral Product Manufacturing	Petroleum and Coal Product Manufacturing	Primary Metal Manufacturing	Pulp, Paper, and Wood Product Manufacturing	Transportation and Machinery Manufacturing	Utilities	Total
Direct Heating	2017	7	27	7	11	-	28	9	18	3	37	7	15	-	171
	2020	14	55	15	23	-	57	18	36	6	78	14	30	-	347
	2025	24	94	26	37	-	90	32	53	11	132	24	45	-	566
	2030	33	133	36	51	-	125	47	71	15	192	34	61	-	799
Steam and Hot Water Systems	2017	0	19	0	6	13	3	8	0	1	2	4	1	-	58
	2020	0	42	1	12	29	6	18	0	1	4	9	3	-	127
	2025	0	73	2	22	43	14	34	1	2	7	15	6	-	219
	2030	0	108	3	33	63	23	55	1	3	11	23	9	-	332
Heating and Ventilation	2017	0	4	3	5	23	5	23	1	0	3	1	16	-	84
	2020	0	7	6	10	44	10	44	2	0	5	3	30	-	161
	2025	0	12	10	17	76	18	76	4	0	10	4	51	-	277
	2030	0	16	13	22	102	24	101	5	0	13	6	68	-	372
CHP Steam	2017	0	1	-	5	0	-	0	-	0	0	2	0	-	8
	2020	0	3	-	10	0	-	0	-	0	0	4	0	-	17
	2025	0	5	-	16	0	-	0	-	0	0	6	1	-	30
	2030	0	9	-	24	1	-	1	-	1	0	8	1	-	45
Gas Turbine	2017	-	-	-	-	-	-	-	-	-	-	-	-	5	5
	2020	-	-	-	-	-	-	-	-	-	-	-	-	15	15
	2025	-	-	-	-	-	-	-	-	-	-	-	-	15	15
	2030	-	-	-	-	-	-	-	-	-	-	-	-	14	14
Steam Turbine	2017	-	-	-	-	-	-	-	-	-	-	-	-	2	2
	2020	-	-	-	-	-	-	-	-	-	-	-	-	7	7
	2025	-	-	-	-	-	-	-	-	-	-	-	-	7	7
	2030	-	-	-	-	-	-	-	-	-	-	-	-	7	7
Grand Total	2017	7	51	11	27	37	36	40	19	4	42	14	32	7	328
	2020	15	107	21	55	73	74	81	39	8	87	29	63	22	674
	2025	24	183	37	92	119	122	143	57	13	149	50	103	22	1,113
	2030	34	266	52	130	166	172	204	77	19	217	71	140	21	1,569

Savings are rounded to the nearest million cubic metre. The value of "0" does not necessarily mean there are no savings.

As shown in Exhibit 154 and Exhibit 155, in 2020, non-large volume Union Gas customers are expected to overtake large volume Union Gas customers as representing the largest share of semi-constrained achievable industrial natural gas savings, compared to the share of unconstrained achievable industrial natural gas savings. Non-large volume Union Gas customers are expected to account for 266 million cubic metres or 39% of semi-constrained achievable industrial natural gas savings, followed by large volume Union Gas customers at 241 million cubic metres or 36%, and Enbridge Gas Distribution customers at 167 million cubic metres or 25%.

Similarly, in 2030, non-large volume Union Gas customers are expected to account for 616 million cubic metres or 39% of semi-constrained achievable industrial natural gas savings, followed by non-large volume Union Gas customers at 560 million cubic metres or 36%, and Enbridge Gas Distribution customers at 393 million cubic metres or 25%.

Exhibit 154 Graph of Industrial Semi-Constrained Achievable Potential Savings by End Use, Year, and Utility

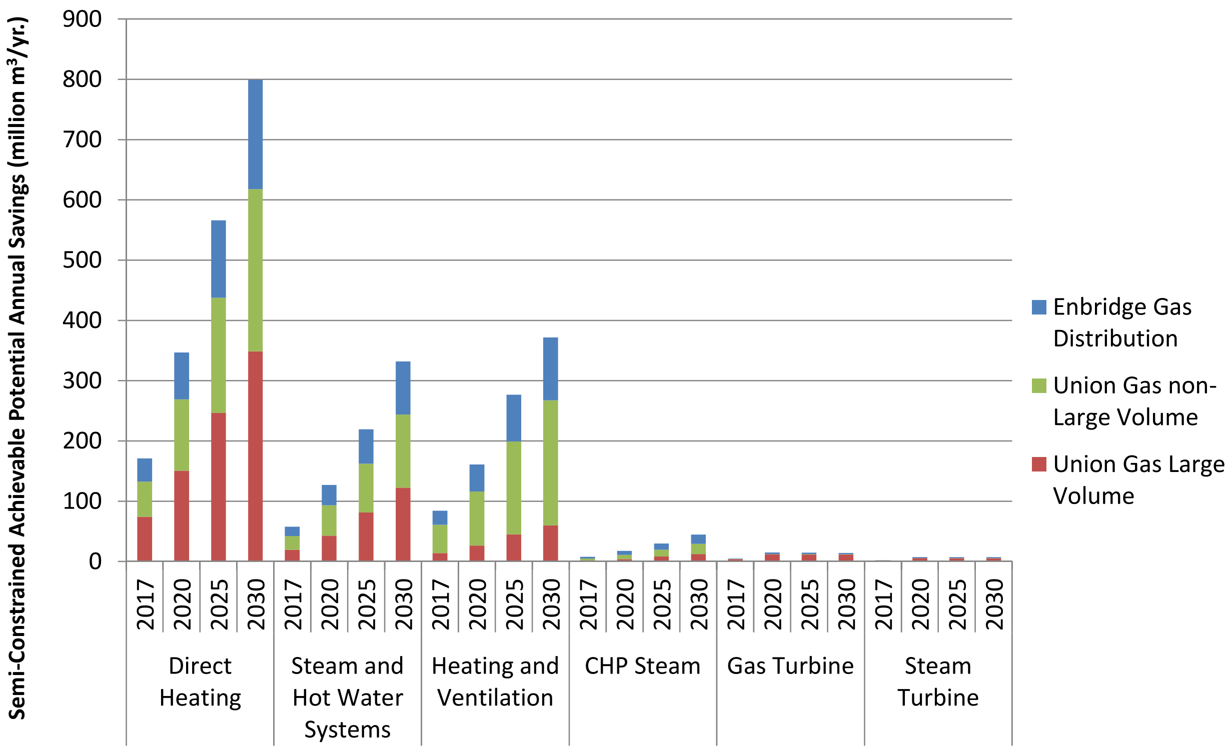


Exhibit 155 Table of Industrial Semi-Constrained Achievable Potential Savings by End Use, Year, and Utility

End Use	Year	Enbridge Gas Distribution	Union Gas non-Large Volume	Union Gas Large Volume	Total
Direct Heating	2017	38	58	74	171
	2020	78	118	151	347
	2025	129	191	246	566
	2030	182	269	349	799
Steam and Hot Water Systems	2017	15	23	19	58
	2020	34	50	43	127
	2025	57	81	81	219
	2030	88	121	123	332
Heating and Ventilation	2017	23	47	14	84
	2020	45	90	27	161
	2025	78	154	45	277
	2030	104	208	60	372
CHP Steam	2017	3	3	2	8
	2020	6	7	4	17
	2025	10	11	8	30
	2030	15	17	12	45
Gas Turbine	2017	1	0	4	5
	2020	2	1	12	15
	2025	2	1	12	15
	2030	2	1	11	14
Steam Turbine	2017	1	0	2	2
	2020	1	0	5	7
	2025	1	0	5	7
	2030	1	0	5	7
Grand Total	2017	82	132	115	328
	2020	167	266	241	674
	2025	277	438	398	1,113
	2030	393	616	560	1,569

6.6.7 Achievable Potential – Constrained Scenario

As was shown in Exhibit 147, the total constrained achievable potential scenario in the industrial sector results in natural savings of 581 million cubic metres by 2020, or 5.6% of 2020 industrial reference case consumption, and 1,181 million cubic metres by 2030, or 11.2% of 2030 industrial reference case consumption. The remainder of this section provides a breakdown of the industrial constrained achievable potential results

As shown in Exhibit 156 and Exhibit 157, in 2020, the direct heating end use is expected to account for 277 million cubic metres or 48% of natural gas savings in the industrial sector, followed by heating and ventilation (146 million cubic metres or 25%), and steam and hot water systems (119 million cubic metres or 21%). Similarly, in 2030, the direct heating end use accounts for 52% (612 million cubic metres) of natural gas savings in the industrial sector, followed by heating and ventilation (258 million cubic metres or 22%), and steam and hot water systems (259 million cubic metres or 22%).

In 2020, the chemical manufacturing sub-sector is expected to achieve the largest share of industrial savings at 87 million cubic metres or 15%, followed by miscellaneous manufacturing (74 million cubic metres or 13%), primary metal manufacturing (66 million cubic metres or 11%), mining, quarrying, and oil and gas extraction (59 million cubic metres or 11%), and transportation and machinery manufacturing (57 million cubic metres or 10%).

Similarly, in 2030 the chemical manufacturing sub-sector is expected to achieve the largest share of industrial savings at 188 million cubic metres or 16%, followed by miscellaneous manufacturing (159 million cubic metres or 13%), primary metal manufacturing (157 million cubic metres or 13%), mining, quarrying, transportation and machinery manufacturing (117 million cubic metres or 10%), and oil and gas extraction (115 million cubic metres or 10%).

As shown in Exhibit 158 and Exhibit 159, in 2020, non-large volume Union Gas customers are expected to account for 243 million cubic metres or 42% of industrial natural gas savings, followed by large volume Union Gas customers at 183 million cubic metres or 32% and Enbridge Gas Distribution customers at 155 million cubic metres or 27%. Similarly, in 2030, non-large volume Union Gas customers are expected to account for 487 million cubic metres or 41% of industrial natural gas savings, followed by large volume Union Gas customers at 368 million cubic metres or 31% and Enbridge Gas Distribution customers at 326 million cubic metres or 28%.

Exhibit 156 Graph of Industrial Constrained Achievable Potential Savings by End Use, Year, and Sub-Sector

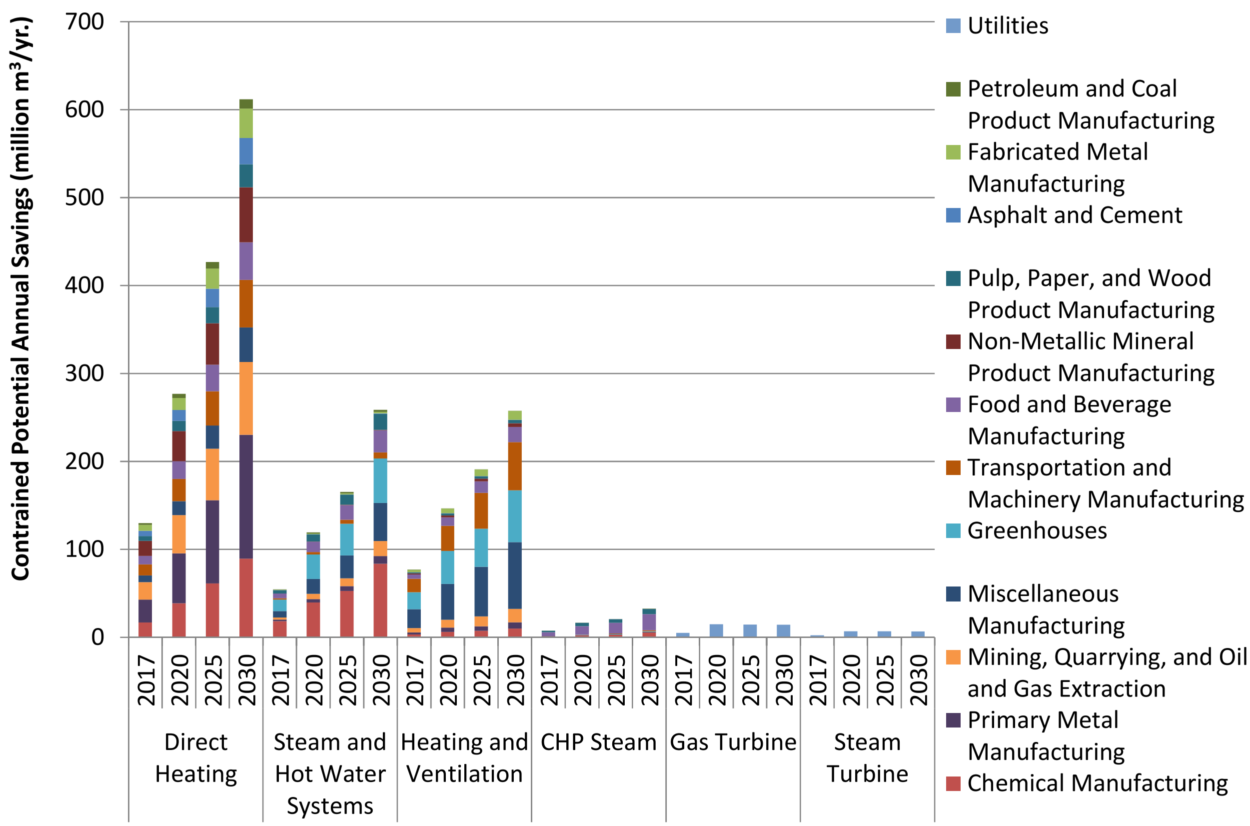


Exhibit 157 Table of Industrial Constrained Achievable Potential Savings by End Use, Year, and Sub-Sector

End Use	Milestone Year	Savings (million m^3/yr.)													
		Asphalt and Cement	Chemical Manufacturing	Fabricated Metal Manufacturing	Food and Beverage Manufacturing	Greenhouses	Mining, Quarrying, and Oil and Gas Extraction	Miscellaneous Manufacturing	Non-Metallic Mineral Product Manufacturing	Petroleum and Coal Product Manufacturing	Primary Metal Manufacturing	Pulp, Paper, and Wood Product Manufacturing	Transportation and Machinery Manufacturing	Utilities	Total
Direct Heating	2017	6	17	7	10	-	20	8	17	2	26	5	13	-	130
	2020	12	39	14	20	-	44	16	34	5	57	12	25	-	277
	2025	21	61	23	30	-	59	26	47	7	95	18	39	-	427
	2030	30	90	33	43	-	83	39	62	10	141	26	54	-	612
Steam and Hot Water Systems	2017	0	18	0	5	13	2	7	0	1	2	4	1	-	55
	2020	0	40	1	12	28	6	17	0	1	4	8	3	-	119
	2025	0	53	1	17	36	9	26	0	1	5	12	4	-	165
	2030	0	84	2	25	51	17	43	1	2	8	18	7	-	259
Heating and Ventilation	2017	0	3	3	5	20	5	21	1	0	3	1	15	-	77
	2020	0	6	5	9	38	9	41	2	0	5	2	29	-	146
	2025	0	7	7	13	43	11	56	3	0	5	3	41	-	191
	2030	0	10	10	17	59	15	76	4	0	7	4	55	-	258
CHP Steam	2017	0	1	-	4	0	-	0	-	0	0	2	0	-	7
	2020	0	2	-	10	0	-	0	-	0	0	4	0	-	16
	2025	0	3	-	12	0	-	0	-	0	0	4	1	-	21
	2030	0	5	-	18	1	-	1	-	0	0	6	1	-	33
Gas Turbine	2017	-	-	-	-	-	-	-	-	-	-	-	-	5	5
	2020	-	-	-	-	-	-	-	-	-	-	-	-	15	15
	2025	-	-	-	-	-	-	-	-	-	-	-	-	15	15
	2030	-	-	-	-	-	-	-	-	-	-	-	-	14	14
Steam Turbine	2017	-	-	-	-	-	-	-	-	-	-	-	-	2	2
	2020	-	-	-	-	-	-	-	-	-	-	-	-	7	7
	2025	-	-	-	-	-	-	-	-	-	-	-	-	7	7
	2030	-	-	-	-	-	-	-	-	-	-	-	-	7	7
Grand Total	2017	6	39	10	25	33	27	36	18	3	30	12	29	7	276
	2020	13	87	20	51	65	59	74	37	6	66	26	57	22	581
	2025	21	124	32	72	80	79	109	51	9	105	37	85	21	825
	2030	30	188	45	104	110	115	159	67	13	157	54	117	21	1,181

Savings are rounded to the nearest million cubic metre. The value of “0” does not necessarily mean there are no savings.

Exhibit 158 Graph of Industrial Constrained Achievable Potential Savings by End Use, Year, and Utility

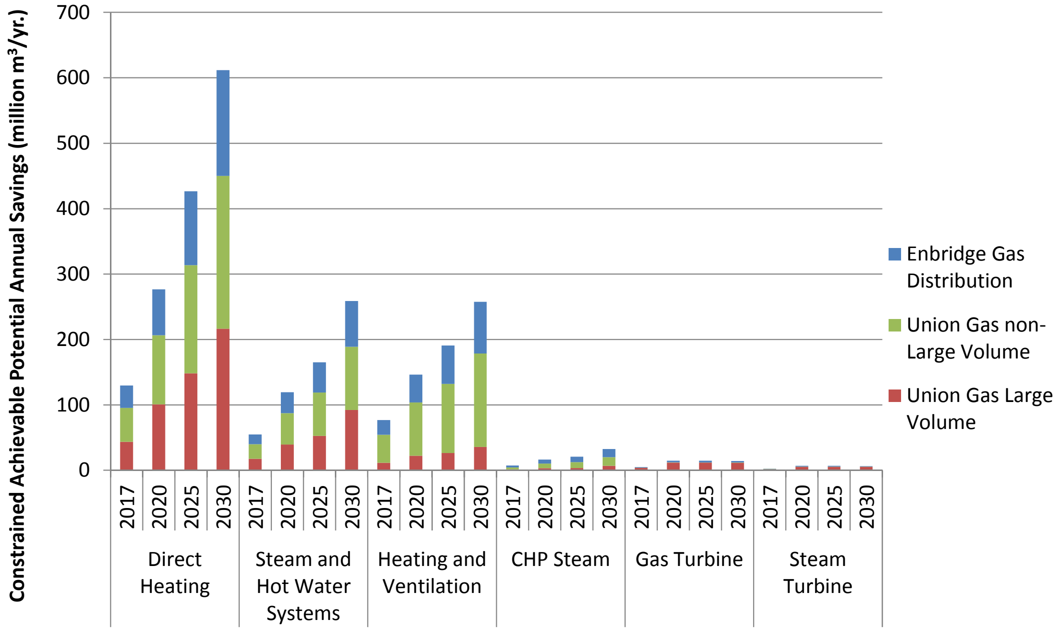


Exhibit 159 Table of Industrial Constrained Achievable Potential Savings by End Use, Year, and Utility

End Use	Year	Enbridge Gas Distribution	Union Gas non-Large Volume	Union Gas Large Volume	Total
Direct Heating	2017	34	52	44	130
	2020	71	105	101	277
	2025	113	165	148	427
	2030	161	234	217	612
Steam and Hot Water Systems	2017	15	22	18	55
	2020	32	48	39	119
	2025	46	66	53	165
	2030	70	97	92	259
Heating and Ventilation	2017	22	43	12	77
	2020	43	82	22	146
	2025	59	106	27	191
	2030	79	143	36	258
CHP Steam	2017	3	3	1	7
	2020	6	7	3	16
	2025	8	9	3	21
	2030	12	14	7	33
Gas Turbine	2017	1	0	4	5
	2020	2	1	12	15
	2025	2	1	12	15
	2030	2	1	11	14
Steam Turbine	2017	0	0	2	2
	2020	1	0	5	7
	2025	1	0	5	7
	2030	1	0	5	7
Grand Total	2017	76	120	80	276
	2020	155	243	183	581
	2025	230	347	248	825
	2030	326	487	368	1,181

6.7 GHG Emission Reductions

The industrial sector GHG emission reductions, which were calculated according to the methodology presented in section 2.9, are presented in Exhibit 167. The results show that the economic potential GHG emission reductions range from approximately 4,642 million kg CO_2 in 2020 to 2,542 million kg CO_2 in 2030. The unconstrained achievable potential GHG emission reductions range from 1,509 million kg CO_2 in 2020 to 3,492 million kg CO_2 in 2030.

Exhibit 160 Industrial GHG Emission Reductions

Year	Reference Case Emissions (million kg CO_2/yr)	Technical Potential		Economic Potential		Unconstrained Achievable Potential		Semi-constrained Achievable Potential		Constrained Achievable Potential	
		GHG Reduction (million kg CO_2/yr.)	Savings Relative to Reference Case (%)	GHG Reduction (million kg CO_2/yr.)	Savings Relative to Reference Case (%)	GHG Reduction (million kg CO_2/yr.)	Savings Relative to Reference Case (%)	GHG Reduction (million kg CO_2/yr.)	Savings Relative to Reference Case (%)	GHG Reduction (million kg CO_2/yr.)	Savings Relative to Reference Case (%)
2015	18,334	3,466	18.9%	3,419	18.6%	220	1.2%	186	1.0%	153	0.8%
2016	19,468	4,761	24.5%	4,686	24.1%	485	2.5%	406	2.1%	337	1.7%
2017	18,759	4,739	25.3%	4,665	24.9%	733	3.9%	611	3.3%	514	2.7%
2018	19,338	4,736	24.5%	4,662	24.1%	991	5.1%	825	4.3%	701	3.6%
2019	19,363	4,726	24.4%	4,652	24.0%	1,249	6.5%	1,040	5.4%	890	4.6%
2020	19,384	4,716	24.3%	4,642	23.9%	1,509	7.8%	1,256	6.5%	1,082	5.6%
2025	19,489	4,663	23.9%	4,595	23.6%	2,459	12.6%	2,074	10.6%	1,536	7.9%
2030	19,596	4,609	23.5%	4,542	23.2%	3,492	17.8%	2,923	14.9%	2,201	11.2%

6.8 Sensitivity Analysis

This section presents the results of the industrial sensitivity analysis based on the methodology discussed in section 2.10.

As shown in Exhibit 161, a 20% increase in participation rates increased the unconstrained potential achievable savings by 4.7% in 2020, while only increasing the semi-constrained and constrained and achievable potential savings by 2.2% and 2.0%, respectively. In 2030, the unconstrained potential achievable savings increase by 6.6%, while the semi-constrained and constrained potential achievable savings increase by 2.7% and 1.0%, respectively.

A 50% increase in avoided costs increased the economic and unconstrained achievable potential achievable savings by 0.3% and 0.6%, respectively, 2020. In 2030, the economic potential and unconstrained achievable potential savings both increased by 0.2%.

Avoided cost factors into the payback calculation and therefore the incentive costs, so there was a modest increase in savings resulting from the avoided cost sensitivity analysis for a given program budget.

Exhibit 161 Industrial Sensitivity Analysis Results

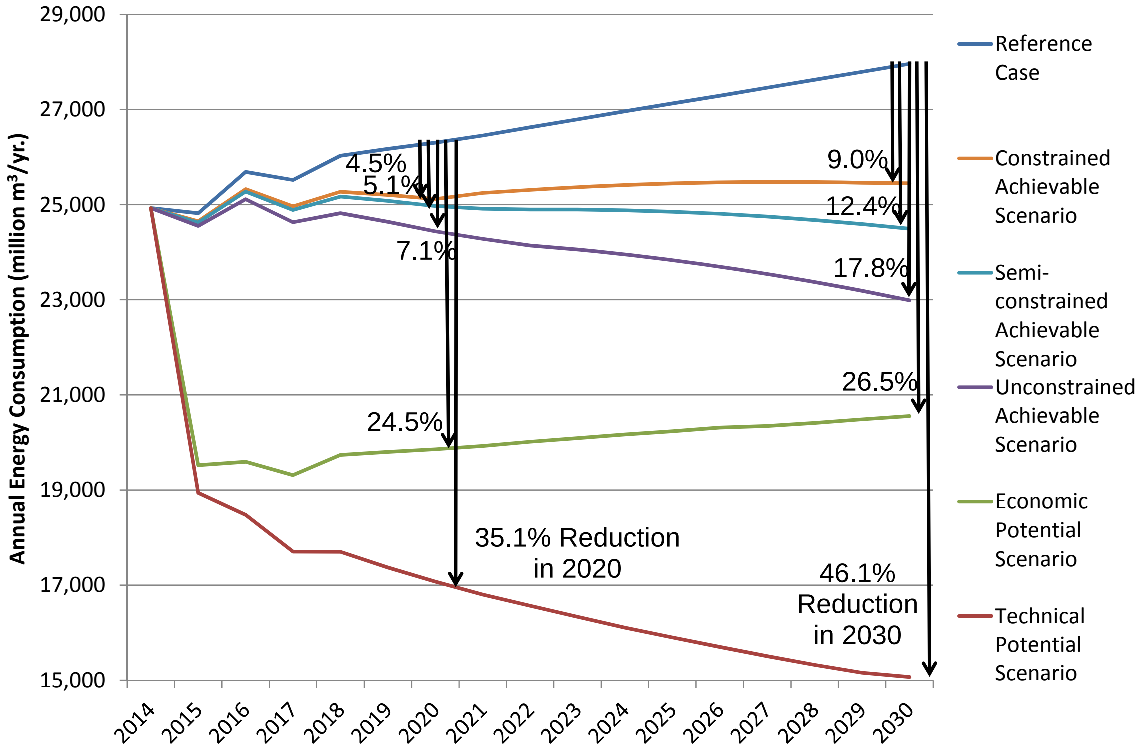
Scenario	Annual Savings (million m^3)		Avoided Cost - 50% Increase				20% Participation Sensitivity			
			Annual Savings (million m^3)		% Change		Annual Savings (million m^3)		% Change	
	2020	2030	2020	2030	2020	2030	2020	2030	2020	2030
Economic Potential	2,492	2,438	2,499	2,442	0.3%	0.2%				
Unconstrained Potential	810	1,874	815	1,878	0.6%	0.2%	849	1,997	4.7%	6.6%
Semi-Constrained Potential	674	1,569					689	1,611	2.2%	2.7%
Constrained Potential	581	1,181					592	1,193	2.0%	1.0%

7 Summary of All Sectors

7.1 Reference Case, Technical, Economic, and Achievable Potential

Exhibit 162 shows a comparison of the reference case and the various potential scenarios analyzed, including: technical and economic potential; and, unconstrained, semi-constrained, and constrained achievable potential consumption for all sectors over the entire study period.

Exhibit 162 Total Reference, Technical, Economic and Achievable Potential Annual Natural Gas Consumption



Technical Potential: The results show that the adoption of all technically-feasible measures, could reduce total consumption by 35.1% by 2020 and 46.1% by 2030.[76]

Economic Potential: Adoption of all measures that are economically viable (i.e. are cost-effective), have the potential to reduce total consumption by 24.5% by 2020 and 26.5% by 2030.

Achievable Potential: The unconstrained, semi-constrained, and constrained achievable potential scenarios could reduce total consumption by 7.1%, 5.1%, and 4.5%, respectively, by 2020, and by 17.8%, 12.4%, and 9.0%, respectively, by 2030.

Exhibit 163 shows the total annual savings for all scenarios included in this study relative to the reference case up until 2030. These are the same numbers that are presented in Exhibit 162,

[76] These large technically-feasible savings available are driven largely by the inclusion of electric air-source and ground-source heat pumps in the residential and commercial sectors of the study. Although these technologies do not currently pass the TRC-plus economic screen, they technically have the potential to eliminate a significant portion of the natural gas space heating in the province by 2030.

presented in further detail, to include more intermediate years. Exhibit 164 shows the corresponding GHG emission reductions for all scenarios.

Exhibit 163 Total Technical, Economic and Achievable Potential Annual Savings Relative to Reference Case

Year	Reference Case Use (million m^3/yr.)	Technical Potential		Economic Potential		Unconstrained Achievable Potential		Semi-constrained Achievable Potential		Constrained Achievable Potential	
		Absolute Savings (million m^3/yr.)	Savings Relative to Reference Case (%)	Absolute Savings (million m^3/yr.)	Relative to Reference Case (%)	Absolute Savings (million m^3/yr.)	Relative to Reference Case (%)	Absolute Savings (million m^3/yr.)	Relative to Reference Case (%)	Absolute Savings (million m^3/yr.)	Relative to Reference Case (%)
2015	24,821	5,880	23.7%	5,299	21.3%	267	1.1%	195	0.8%	171	0.7%
2016	25,690	7,211	28.1%	6,096	23.7%	575	2.2%	414	1.6%	362	1.4%
2017	25,518	7,811	30.6%	6,205	24.3%	891	3.5%	631	2.5%	555	2.2%
2018	26,029	8,326	32.0%	6,290	24.2%	1,209	4.6%	859	3.3%	758	2.9%
2019	26,172	8,803	33.6%	6,369	24.3%	1,534	5.9%	1,094	4.2%	969	3.7%
2020	26,306	9,233	35.1%	6,448	24.5%	1,869	7.1%	1,338	5.1%	1,187	4.5%
2025	27,128	11,229	41.4%	6,891	25.4%	3,295	12.1%	2,276	8.4%	1,681	6.2%
2030	27,962	12,896	46.1%	7,409	26.5%	4,973	17.8%	3,468	12.4%	2,510	9.0%

Exhibit 164 Total Greenhouse Gas Emission Reductions from all Scenarios

Year	Reference Case Emissions (million kg CO_2/yr)	Technical Potential		Economic Potential		Unconstrained Achievable Potential		Semi-constrained Achievable Potential		Constrained Achievable Potential	
		GHG Reduction (million kg CO_2/yr)	Savings Relative to Reference Case (%)	GHG Reduction (million kg CO_2/yr)	Savings Relative to Reference Case (%)	GHG Reduction (million kg CO_2/yr)	Savings Relative to Reference Case (%)	GHG Reduction (million kg CO_2/yr)	Savings Relative to Reference Case (%)	GHG Reduction (million kg CO_2/yr)	Savings Relative to Reference Case (%)
2015	46,241	10,955	23.7%	9,872	21.3%	498	1.1%	364	0.8%	318	0.7%
2016	47,860	13,434	28.1%	11,356	23.7%	1,072	2.2%	771	1.6%	675	1.4%
2017	47,541	14,552	30.6%	11,560	24.3%	1,659	3.5%	1,175	2.5%	1,033	2.2%
2018	48,492	15,512	32.0%	11,717	24.2%	2,252	4.6%	1,600	3.3%	1,413	2.9%
2019	48,759	16,401	33.6%	11,866	24.3%	2,858	5.9%	2,038	4.2%	1,805	3.7%
2020	49,008	17,201	35.1%	12,013	24.5%	3,482	7.1%	2,492	5.1%	2,212	4.5%
2025	50,539	20,920	41.4%	12,838	25.4%	6,138	12.1%	4,240	8.4%	3,132	6.2%
2030	52,093	24,025	46.1%	13,803	26.5%	9,265	17.8%	6,460	12.4%	4,677	9.0%

Exhibit 165 presents a summary of the achievable potential savings and program costs for all sectors' achievable potential scenarios in 2020 and in 2030.

Exhibit 165 Table of All Sectors' Achievable Potential Savings and Program Cost Results[77]

Value	Unconstrained		Semi-Constrained		Constrained	
	Year					
	2020	2030	2020	2030	2020	2030
Annual Savings (million m^3/yr.)	1,869	4,973	1,338	3,468	1,187	2,510
Measure Lifecycle Savings (million m^3)	28,582	82,756	18,909	55,386	14,115	39,831
Value of Savings (million $)	16,456	96,600	12,938	78,266	9,142	58,628
Program Spending to Milestone Year (million $)	3,298*	11,544*	893	3,330	666	1,917
Average Annual Program Spending (million $/yr.)	550*	722*	149	208	111	120
Average Program Spending up to Milestone Year ($/$m^3$)	0.12*	0.14*	0.05	0.06	0.05	0.05

**Note: These are not specific program costs but are the total costs for the scenario.*

Unconstrained program results: With unconstrained budget, all sector programs combined could achieve 1,869 million cubic metres of annual savings, or 28.6 billion cumulative cubic metres of savings by 2020, at a total cost of $3.3 billion or on average $550 million per year. All sector programs combined could achieve 5.0 billion cubic metres of annual savings, or 82.8 billion cumulative cubic metres of savings by 2030, at a total cost of $11.5 billion or on average $722 million per year.

Semi-constrained program results: A program budget for all sectors of $893 million for 2015-2020, or $149 million per year, could achieve 1.3 billion cubic metres of annual savings, or 18.9 billion cumulative cubic metres of savings, by 2020. A program budget of $3.3 billion to 2030 could achieve 3.5 billion cubic metres of annual savings, or 55.4 billion cumulative cubic metres of savings, by 2030. This level of spending up to 2030 represents 29% of the total spending of the unconstrained program, while the total lifecycle savings of natural gas represent 67% of the total savings of natural gas in the unconstrained program.

Constrained program results: Under budget allocations for all sectors of $666 million for 2015-2020, or $111 million per year, programs could achieve 1.2 billion cubic metres of annual savings, or 14.1 billion cumulative cubic metres of savings by 2020. Under a budget allocation of $1.9 billion to 2030, programs could achieve 2.5 billion cubic metres of annual savings, or 39.8 billion cumulative cubic metres of savings by 2030. This level of spending up to 2030 represents 17% of the total spending of the unconstrained program, while the total lifecycle savings of natural gas represent 48% of the total savings of natural gas in the unconstrained program.

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[77] See footnote 64 for details on the values in this table.

7.2 Sensitivity Analysis

Exhibit 166 shows the sensitivity results for all sectors. The sensitivity analysis shows that increasing the avoided costs by 50% increases the economic potential savings by 16% in 2020 and 24% in 2030. It also increases the unconstrained achievable potential savings by 16% in 2020 and 15% in 2030. The effects on the semi-constrained and constrained potential of varying the avoided cost were negligible, so these results were omitted. Similarly, there would be no effect on the economic potential resulting from varying the participation rate, so these results are also omitted.

The results in Exhibit 166 also show that a 20% increase in participation rates increases all the unconstrained, semi-constrained, and constrained achievable potential scenario savings results by 7%, 4%, and 5%, respectively, in 2020, In 2030, the annual savings increases by 8%, 3%, and 1%, for the unconstrained, semi-constrained and constrained achievable potential scenarios, respectively.

These results show that the savings potential is less sensitive to participation, especially when the program spending budget is constrained or semi-constrained. In both the residential and commercial sector, the additional measures were relatively expensive compared to the measures that were already part of the original achievable constrained and semi-constrained scenarios, limiting any additional measures to the constrained and semi-constrained scenarios under the participation sensitivity scenario.

Exhibit 166 Sensitivity Results for All Sectors

Scenario	Annual Savings (million m^3)		Avoided Cost - 50% Increase				20% Participation Sensitivity			
			Annual Savings (million m^3)		% Change		Annual Savings (million m^3)		% Change	
	2020	2030	2020	2030	2020	2030	2020	2030	2020	2030
Economic Potential	6,448	7,409	7,484	9,181	16%	24%				
Unconstrained Potential	1,869	4,973	2,161	5,741	16%	15%	1,992	5,373	7%	8%
Semi-Constrained Potential	1,338	3,468					1,393	3,583	4%	3%
Constrained Potential	1,187	2,510					1,245	2,539	5%	1%

8 Comparison with Prior Potential Studies

8.1 Introduction

In this section we compare the results of this study with the results of previous natural gas conservation potential studies conducted by both ICF (formerly Marbek) [78] and Navigant[79] and an analysis of studies carried out in several jurisdictions across North America. The comparison is split into two sections, the comparison of savings and the comparison of methodology. In the comparison of savings section we compare the end of study and annual technical, economic and achievable potential savings. The next section compares the study methodology between the current study and past ICF and Navigant studies.

8.2 Comparison of Methodology

Below is an overview of the differences in methodology between this study and previous ICF natural gas studies (carried out for Enbridge Gas Distribution, Union Gas, and FortisBC):

- **Milestones:** ICF's previous studies modeled achievable potential using either 3-year or 5-year milestones. This study employs annual (1-year) milestones, although the results are reported in 3-5 year increments. As such, it was not necessary to interpolate the results for intervening years for any of the exhibits that were created.
- **Number of measures:** In general, the number of measures being considered for this study is significantly larger than the number of measures considered in our previous studies
- **Achievable potential consultations:** In our previous studies, ICF carried out one-day achievable potential workshops with key market actors for each sector using a Delphi panel approach to inform our achievable potential participation estimates. For this study, we employed targeted interviews of key market actors to inform the participation estimates.
- **Achievable potential approach:** There are a number of different ways to determine the program participation rates for the achievable potential scenarios. Navigant's approach was based on payback acceptance curves, while ICF relied on consultations, as noted above.
- **Achievable potential scenarios:** ICF's previous studies included two achievable potential scenarios (i.e. static or BAU and aggressive). This study includes three achievable potential scenarios (i.e. Constrained, Semi-Constrained, and Unconstrained) based on specific budget levels set out in the OEB's 2015-2020 DSM Decision.

[78] Natural Gas Energy Efficiency Potential Study Update 2007-2017, prepared for Union Gas, ICF Marbek, 2011.

Conservation Potential Review 2010-2030, prepared for Fortis BC, ICF Marbek, 2011.

Natural Gas Energy Efficiency Potential Update 2007-2017, prepared for Enbridge, Marbek, 2008.

[79] Natural Gas Energy Efficiency Potential Study 2014-2024 prepared for Enbridge, Navigant, 2015.

8.3 Comparison of Results

The meta-study developed by ACEEE (American Council for an Energy Efficient Economy), “Cracking the TEAPOT: Technical, Economic, and Achievable Energy Efficiency Potential Studies” published in 2014 was reviewed as part of the comparison of savings. The meta-study reviewed and provided results for 45 publicly available studies published since 2009 for utilities and regions in the US. Overall the meta-study found that for natural gas, average annual maximum achievable savings range from 0.1% to 2.4% with a median of 0.9%. The results of this study are in line with the meta-study median, with average annual savings in the semi-constrained achievable potential of 0.8%.

The meta-study study also found a positive correlation between avoided costs and energy savings potential, which is in line with our expectations. Also of note, the meta-analysis found that there was no apparent correlation between geography and energy efficiency potential. Some states and utilities that were evaluated in the study estimated significant levels of achievable potential of 1.5% average annual savings or higher.

Presented in Exhibit 167 is a comparison of results between previous ICF and Navigant natural gas potential studies. The results from the 2009 Minnesota Gas Energy Efficiency Potential Study completed by Navigant and analyzed by ACEEE was included in the comparison as it was the only natural gas study included in the ACEEE meta-analysis with technical and economic results available for comparison.

It should be noted that some of the previous studies did not report technical potential savings, some information on achievable was missing, and/or the number of achievable scenarios differed between studies. In this comparison of results there are a number of varying factors that may influence the results, including variations in avoided costs and differences in the methodologies that were employed, as was noted earlier.

As also shown in Exhibit 167, the overall technical potential natural gas savings estimated in this study (46%) is higher than the technical potential savings that were identified by Navigant in their 2015 study for Enbridge Gas Distribution (35%) and for Minnesota (36%). However, the time periods considered in each of these studies was different, so it is more appropriate to consider annual technical potential savings, which were 3.1% in this study, 3.5% in the Navigant Enbridge study, and 3.6% in the Navigant Minnesota study. These results indicate that the technical potential results of this study are slightly more conservative than those of the other two studies.

In this study, the economic potential savings were estimated to be 26% by 2030, or about 1.8% annually, versus the Navigant Enbridge Gas Distribution study estimate of 25%, or 2.5% annually. The economic potential savings from the other ICF/Marbek studies were also found to be higher than those of the current study. Some of these differences are likely due to different avoided costs between the studies, as well as slightly increased penetration of the various measures since the previous studies were completed, due to on-going initiatives.

The annual achievable potential results in this study are quite similar in magnitude to the results of the Navigant Enbridge Gas Distribution study, with both studies estimating annual achievable potential savings of 0.8%.

Exhibit 167 Comparison of End of Study and Annual Technical, Economic and Achievable Potential Savings

Year	Title	Author	Region (Utility)	Study Period	# Years	Natural Gas Cumulative Savings At End of Study Period					Natural Gas Average Annual Savings				
						Tech	Econ	Achievable Low	Achievable Med	Achievable High	Tech	Econ	Achievable Low	Achievable Med	Achievable High
2016	Natural Gas Conservation Potential Study 2016	ICF	Ontario	2015-2030	15	46%	26%	9%	12%	18%	3.1%	1.8%	0.6%	0.8%	1.2%
2015	Natural Gas Energy Efficiency Potential Study	Navigant	ON (Enbridge)	2014-2024	10	35%	25%		8%		3.5%	2.5%		0.8%	
2011	Natural Gas Energy Efficiency Potential Study: Update 2011	ICF Marbek	ON (Union)	2007-2017	10		39%	8%		14%		3.9%	0.8%		1.4%
2011	Conservation Potential Review – 2010 FortisBC Report	ICF Marbek	Fortis BC	2010-2030	20		14%	6%		9%		0.7%	0.3%		0.5%
2009	Natural Gas Energy Efficiency Potential: Update 2008	Marbek	ON (Enbridge)	2007-2017	10		26%			11%		2.6%			1.1%
2009	Natural Gas Energy Efficiency Potential Study	Marbek	ON (Union)	2007-2017	10		30%	10%		15%		3.0%	1.0%		1.5%
2009	MN Gas EE Potential	Navigant	MN	2009-2019	10	36%	20%				3.6%	2.0%			1.8%

9 Recommendations

Conservation potential studies for the province of Ontario are expected to be conducted on a three-year cycle. The purpose of this section is to identify ways to enhance the next natural gas conservation study, both by capturing some of the successful features of this study and by improving on other aspects.

9.1 Successes to Retain

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

- The Technical Working Group was dedicated to producing a good study, and provided review and constructive feedback that the consultants found extremely valuable. It was important that the group represented a variety of perspectives.
- The development of TRM documents prior to the beginning of the study was a valuable contribution. Ideally, a definitive set of TRM substantiation documents should be compiled before the next request for proposals is released, so that it can be made available to bidders.
- The availability of recent end use surveys from the gas utilities was valuable for both the residential and commercial sectors.[80] The next end use surveys should be timed to produce results before the next request for proposals is released.

9.2 Recommended Improvements

Aspects of the current study that could be improved in the next study include the following:

- The next study should have a longer timeframe for completion. In particular, this extended period would allow for more detailed review and more flexibility for the contractor to make modelling changes in response to feedback.
- The next study should consider using a modified Delphi workshop approach to developing estimates of measure participation. The interview approach used in this study worked adequately well, but the process is enhanced when there is real-time interaction between interviewees with varying viewpoints.
- If the natural gas and electricity conservation potential studies will be occurring simultaneously next time, the next study should include some opportunities for collaboration between them. This interaction would potentially enhance the study in several ways, including:
  - The reference case could include improved estimates of the effects of conservation activities by other actors, particularly the electric utilities
  - More comprehensive electricity and water savings could be included in the assumptions about the measures
  - Measures that save both electricity and gas could be included in programs operated jointly between the gas and electric utilities. This could be reflected in the program cost assumptions for both studies (i.e., the program costs could be reduced on the gas side if part is to be paid by the electric utility).

[80] It should be noted that the scope and accuracy of future commercial end use surveys could be improved significantly. In addition, questions should focus on the distribution of energy consumption for different types of equipment.

- Fuel switching could be included in the scope of the study

- It should be defined clearly where a conservation potential study ends and where program planning begins. Development of program cost assumptions for the measures, and optimization of which measures can be included in specified budgets must be relatively mechanical procedures in the context of a conservation potential study looking at dozens or hundreds of conservation measures. Subsequent program planning will repeat much of this effort in greater detail and based on more robust data. In the next study, it may be helpful to place clear limits on the level of detail and accuracy expected of the program costing component of the study.
- The program costing component of the next study may also be enhanced by including a stage where the consultant assembles the various measures into program bundles. The optimization process of estimating how much program activity could be accomplished for specified budget levels would then be conducted at the bundle level, rather than at the level of individual measures. This would likely reduce the savings estimate slightly, but may be a simpler approach.
- The results of the next study could be enhanced by making more use of empirical data from existing programs and building improvement projects, to "ground truth" the savings that are achievable from real measures applied to real buildings.
- If the next study is to identify savings for specific sub-sectors, such as large volume industrial customers or low-income residential customers, data divided according to these categories should be provided to the consultant performing the study. For example, residential end use surveys targeting the low-income sector specifically would be very useful.
- Measure savings in the present model are based on baseline efficiencies representing the average in each category of buildings. For example, in residential, savings for an insulation measure would be calculated based on the average baseline insulation in a given vintage of dwellings. This does not capture the range of possible insulation levels in that group of dwellings. The next study could be enhanced by including several variants of certain measures, in order to capture niche markets in which they may be more economically attractive.
- The sensitivity analysis in the next study would be enhanced through varying more parameters and including more points for each parameter.
- The Ontario government released its Climate Change Action Plan while this study was being completed.[81] Subsequent studies and any updates to this study should account for the impacts of this plan.

[81] Ontario's Five Year Climate Change Action Plan: 2016-2020, Ontario Ministry of Environment and Climate Change, 2016, available at: http://www.applications.ene.gov.on.ca/ccap/products/CCAP_ENGLISH.pdf

Appendix A Glossary

Achievable Potential:

The portion of the economic conservation potential that is achievable through utility interventions and programs given technical, economic and market adoption barriers.

Avoided Cost:

By reducing natural gas consumption and capacity requirements through the implementation of demand side management programs, the utilities avoid the cost of having to buy natural gas on the open market, contract for long term supply, find new sources, or paying for storage. This avoided cost is used to develop a benchmark against which the cost of energy efficiency measures can be compared.

Base Year:

The Base Year is the year to which all potentials will be compared. It provides a detailed description of where and how natural gas is currently used in each sector. For this study, it is the calendar year 2014. The modelled base year energy use is calibrated against utilities' actual sales for 2014.

Benefit/Cost Ratio:

The measure benefit/cost ratio indicates the relative attractiveness of the measures. A measure that has a benefit/cost ratio in excess of 1.0 has benefits which outweigh its costs. Similarly, a measure with a benefit/cost ratio that is well in excess of one (e.g., 3.0) means that it is very attractive. A measure with a benefit/cost ratio of less than 1.0 has costs that outweigh its benefits. The benefits included in the numerator and the costs included in the denominator of the ratio will depend on the perspective for whom the ratio is being developed. For example, if the ratio is being calculated from the perspective of a program administrator, only the benefits and costs experienced by the administrator of the program would be included.

Cogeneration / Combined Heat and Power (CHP):

The simultaneous production of electric or mechanical energy and useful heat energy from a single fuel source.

Combustion Efficiency:

The ratio of energy released during combustion to the potential chemical energy available in the fuel.

Demand-Side Management (DSM)

Actions taken by a utility or other agency which are expected to influence the amount or timing of a customer's energy consumption.

Discount Rate

The interest rate used in calculating the present value of expected yearly benefits and costs.

Economic Potential:

The Economic Potential is the savings in natural gas consumption due to energy efficient measures whose cost-effectiveness exceeds the threshold for the TRC-plus cost effectiveness test.

Efficiency:

The ratio of the useful energy delivered by a dynamic system to the amount of natural gas energy supplied to it.

Emerging Measures:

There are technologies that are new to the market or that are commercially available but underused and expected to reach full commercialization during the study period, and technologies likely to emerge during the study period but that are not yet market ready

Energy Audit:

An on-site inspection and cataloguing of energy using equipment/buildings, energy consumption and the related end-uses. The purpose is to provide information to the customer and the utility. Audits are useful for load research, for DSM program design and for identification of specific energy savings measures.

Energy Use Intensity (EUI):

The ratio of energy consumed per application or end use. For example, cubic metres per square metre of heated office space per day, or cubic metres per tonne of aluminium produced. All else being equal, energy intensity increases as energy efficiency decreases.

End use:

The services of economic value to the users of energy. For example, space heating is an end use, whereas natural gas sold to the office tenant is of no value without the equipment (furnaces, boilers, etc.) necessary to convert the natural gas into thermal energy. End use is often used interchangeably with energy service.

Energy Service:

An amenity or service supplied jointly by energy and other components/equipment such as buildings and heating equipment. Examples of energy services include residential space heating, commercial cooking, smelting, and public transit. The same energy service can frequently be supplied with different mixes of equipment and energy.

Financial Incentive:

Certain financial features in the utility's demand side management programs designed to motivate customer participation. These may include features designed to reduce a customer's net cash outlay, payback period or cost of finance to participate in a specific demand side management measure or technology.

Fuel Share:

The proportion of requirements for a specific service that is met using a certain fuel. In the commercial sector, fuel shares are normalized on a floor area basis. For example, a natural gas fuel share of 90% for space heating in the Large Office sub sector implies that 90% of the sub sector floor space is heated using natural gas.

Interactive Effects:

In the context of natural gas use, interactive effects may refer to the increase in gas consumed by heating equipment required to offset a decrease in “waste” heat generated by more efficient electrical fixtures or appliances after retrofit or replacement. In this study, such increases in natural gas consumption due to changes in electricity consumption are incorporated in the reference case. Interactive effects also refer to interactions between measures that affect the same end use. For example, installation of efficient windows or attic insulation will typically reduce the savings that can be achieved by subsequently installing a new thermostat.

Measure Applicability:

The overall measure applicability would be the product of the fraction of end use applicability and the technical-barrier applicability. The fraction of end use applicability refers to the portion of end use that is affected by the measure. For example, the savings resulting from low-flow showerheads only affects the shower portion of the domestic hot water consumption. The fraction of end use applicability also considers the portion of the end use that the measure can be applied to. For example, the furnace upgrade measures are applicable only to the portion of the space heating in dwellings with ducts because the measure cost does not include the addition of ducts. The technical-barrier applicability refers to technical barriers to adoption, such as venting restrictions.

Measure Life:

The estimated median number of years that the measures installed under a program are still in place and operable. Measure life incorporates: field conditions, obsolescence, building remodelling, renovation, demolition, and occupancy changes.

Measure Total Resource Cost-Plus (TRC-plus):

The measure TRC-plus is a cost/benefit analysis of the net present value of energy savings that result from an investment in an efficiency or fuel choice technology or measure. The measure TRC-plus calculation considers a measure's full or incremental capital cost (depending on application) plus any change (positive or negative) in the combined annual energy and operation and maintenance (O&M) costs. This calculation uses the avoided natural gas price with a 15% non-energy benefit adder,[82] electricity supply costs, the life of the technology, and the selected discount rate. In this study, TRC-plus is expressed as a ratio of benefits divided by costs, with both the numerator and denominator calculated as net present values.

A technology or measure with a TRC-plus benefit/cost ratio of 1.0 or greater is included in the technical, economic, and achievable potential analyses. A measure with a TRC-plus benefit/cost ratio below 1.0 is not considered economically attractive and is therefore included only in the technical potential analysis Consistent with OEB DSM Guidelines, a lower benefit/cost ratio threshold of 0.7 was used for measures applied to low-income sub-sectors.

Natural Change in Natural Gas Energy Intensity:

The future change in natural gas energy intensity in a given end use that is expected to occur in the absence of demand side management programs. In developing an estimate of natural change in natural gas energy intensity it is necessary to make an explicit assumption about the future prices of electricity and competing fuels. Natural change includes the effects of natural conservation activities caused by customers replacing or upgrading their equipment in the normal course of events. Replacement equipment is assumed to meet new codes and standards as they come into force, and also to continue current buying patterns of efficient or less efficient new equipment.

Natural Gas Conservation:

Activities by utilities or natural gas users that result in a reduction of natural gas use without adversely affecting the level or quality of natural gas service provided. Natural gas conservation measures include substitution of high-efficiency furnaces for standard efficiency ones, faucet aerators that reduce hot water usage, insulation in residences, etc. In this study, natural gas conservation includes improvements to codes and standards that are expected to be implemented on specific dates within the study period. In addition, where current buying patterns include a market share for high-efficiency equipment, those buying patterns are assumed to continue.

Penetration:

The portion of end users that have adopted a certain measure or will adopt it in the future. Reference case penetration is the portion of users that have adopted the measure in the base year or are expected to do so in the future without any new utility programs. The penetration achieved under a conservation potential scenario is the reference penetration plus the additional penetration induced in the scenario.

[82] See footnote 23 for a description of the 15% adder.

Participation:

The portion of eligible end users who will adopt a certain measure, expressed as a fraction of the economic potential for the measure. Eligible users refers to those who can technically apply the measure, have not already adopted the measure, and for whom the measure passes the TRC-plus test. Participation is used to estimate achievable potential as a fraction of economic potential.

Reference Case:

Provides a forecast of natural gas sales that includes natural conservation (that which would occur in the absence of DSM programs) but no impacts of utility DSM programs. The reference case for the study is based on the 2014 base year and the utilities' load forecasts.

Retrofit:

A measure category that includes the addition of an efficiency measure to an existing facility such as insulation or control gaps (for example, to close hot air leaks through cracks and other gaps).

Saturation:

The portion of dwellings (in the case of the residential sector) or floor area (in the case of the commercial sector) that receive a specific energy service. For example, a saturation of 86% for space cooling in the large office sub sector means that 86% of the sub sector floor space is cooled (regardless of fuel used to provide that cooling).

Sector:

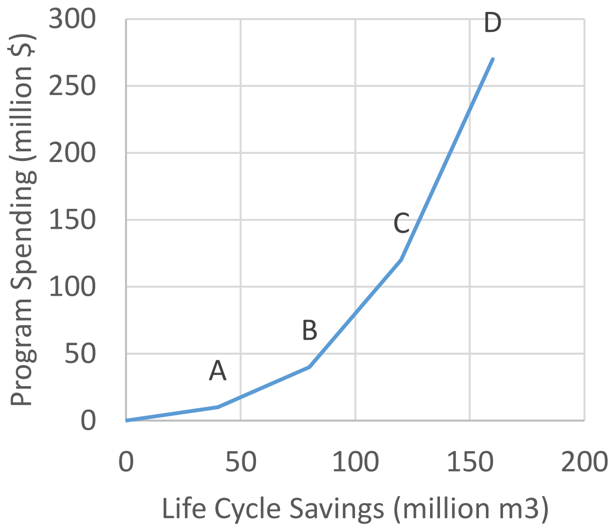
A group of customers having a common type of economic activity. This natural gas conservation potential study includes the residential, commercial, and industrial sectors.

Sub-sectors:

A classification of customers within a sector by common features. Residential sub-sectors are defined by type of home (single-family detached or attached). Commercial sub-sectors are generally defined by type of commercial service (retail and wholesale trade). Industrial sub-sectors are defined by product type (pulp and paper, fabricated metal products, chemicals, etc.).

Supply Curves:

A graph that depicts the volume of energy available either from supply-side or demand-side options, in ascending order of cost. In this study, supply curves have been used to estimate the level of savings that can be achieved for a specific budget. Consequently, the vertical axis is program spending and the horizontal steps in a more traditional supply curve have been replaced by sloped lines that show measure savings horizontally and program spending vertically. For example, steps A through D in the curve below show four program options arranged in a supply curve.



Technical Efficiency:

Efficiency of a system, process, or device in achieving a certain purpose, measured in terms of the physical inputs required to produce a given output.

Technical Potential:

The technical potential is the total natural gas savings resulting from the implementation of all technically feasible energy efficiency measures, regardless of cost effectiveness or market acceptance.

Appendix B Measure Descriptions

Residential

Residential Measure Name	End Use	Measure Description
95% or Higher Efficiency Furnace	Space heating	The measure is for the installation of condensing furnaces with an annual fuel utilization efficiency (AFUE) of 95% or higher. Condensing gas furnaces achieve savings through the utilization of a sealed, super insulated combustion chamber, more efficient burners, and multiple heat exchangers that remove a significant portion of the waste heat from the flue gasses. As the heat exchangers remove waste heat from the flue gases, the gases condense and the resulting condensate must be drained.
Active Solar Water Heating Systems	Domestic water heating	Solar DHW systems use the energy of the sun to heat water. The primary components of a solar water heating system are a solar collector, a heat transfer fluid and a well-insulated storage tank. Due to Canada's colder climate and the higher likelihood of freezing, active closed-loop systems are generally used. These systems use a pump to circulate a non-freezing heat transfer fluid through the collectors and then through a heat exchanger so that the thermal energy can be transferred to the water. Solar DHW systems are generally not sized to supply all of the annual requirement for water heating in the home, because if the system is sized for cloudy winter periods it will have enormous excess capacity during sunny summer periods, and will cost far too much to install. The system analyzed in this study meets approximately 2/3 of the annual requirements.
Adaptive Thermostats	Space heating	Adaptive thermostats employ advanced features beyond conventional programmable thermostats. These more sophisticated, yet easier to use devices, address key usability and programming issues of traditional units. Functions may include remote access for additional flexibility and control, an important feature when the user's plans for the day have changed.
Air Leakage Sealing and Insulation (Old Homes)	Space heating	This measure is targeted at homes that are at least 30 years old, since many of these homes haven't had any work done to improve insulation and air-sealing deficiencies and it is generally most cost-effective to upgrade the insulation and the air sealing at the same time. This includes wall, attic, foundation, and crawlspace retrofits of older homes but, for the purposes of this analysis, it is assumed that a retrofit is being conducted on the attic. The air-sealing portion of the work could be accomplished by segmenting the attic. In each segment, the existing insulation could be moved to one side and polyurethane foam could be sprayed in (serves as an air sealant in addition to its insulating

Residential Measure Name	End Use	Measure Description
		properties). It may also be necessary to install or refurbish top plates to prevent airflow into the attic through exterior wall cavities. Other considerations that would increase the cost of the air-sealing portion of the work and may be present in some homes include sealing pot lights and kitchen or bathroom exhaust piping. When completed, these measures would dramatically improve the air tightness of an older home. The attic insulation could subsequently be cost-effectively improved with cellulose insulation.
Attic Insulation	Space heating	Insulation levels can be increased in attics by blowing insulation into the attic spaces to fill and cover the space within the roof frame. One technique is to make sure loose-fill or batt insulation fills the attic floor joists fully and then add an additional layer of unfaced fibreglass batt insulation across the joists. To reduce cost, it is also possible to blow in cellulose insulation on top of the existing insulation instead.
Basement Wall Insulation	Space heating	In many homes, the basement is often under-insulated or even left uninsulated. Increasing the insulation level in basements can be achieved in a number of ways, including constructing a new insulated frame wall, moving the existing frame wall to increase the insulation level, adding extra insulation to the existing frame wall, adding rigid board insulation to the exterior of the foundation, or using a combination of interior and exterior rigid board insulation. As a lower cost alternative, it is also possible to use polyurethane foam.
Close Windows and Blinds	Space heating	Blinds and curtains can effectively increase the insulation value of a window, saving energy in winter to heat at night when the temperature is typically cooler. Thick insulating curtains can add up to R-7 of insulation. A generic mid-weight curtain is considered in this measure.
Condensing Gas Boilers	Space heating	High-efficiency condensing boilers feature advanced heat exchanger designs that extract more heat from the flue gases before they are exhausted. So much heat is extracted that the flue gases condense and must be discharged as a condensate rather than a gas. In retrofit applications where condensing boilers are replacing non-condensing units, it may be necessary to modify the radiating system. Otherwise, the units may not actually condense the flue gas and realize their full efficiency potential.
Condensing Gas Water Heaters	Domestic water heating	Condensing water heaters feature advanced heat exchanger designs that extract more heat from the flue gases before they are exhausted. So much heat is extracted that the flue gases condense and must be discharged as a condensate rather than a gas. As a result, the efficiency of these types of water heaters is significantly higher than standard water heaters.

Residential Measure Name	End Use	Measure Description
Crawlspace Insulation	Space heating	Insulation levels remain below code in many homes that include crawlspaces as part of the basement design. If the floor is exposed, it would first be necessary to install a vapour barrier (e.g., 6 mil (600 gauge/0.15 mm) polyurethane barrier). Polyurethane foam could then be applied to the ceiling of the crawlspace (or the outer walls if there are pipes running below the floor). In addition to increasing the insulation of the crawlspace, this would help to eliminate any air leaks. Co-benefits of improved crawlspace insulation include improved thermal comfort, fewer drafts, and less condensation.
DHW Recirculation Systems (e.g. Metlund D'MAND®)	Domestic water heating	When turning on the hot water tap, it often takes a long time before hot water begins to flow. DHW recirculation systems can be used to pump hot water to a faucet at the demand of a user, getting hot water to the fixture four to five times quicker than traditional systems. Water that is in the hot water lines is pumped back to the water heater either through the cold water lines or through a dedicated line. This pumping continues until the temperature of the hot water at the point of use reaches a specified value. In retrofit situations, this pumping system is generally installed at the faucet that is furthest away from the water heater and the system is enabled by remote activation from the other points of use. Along with improved convenience and water savings (since water isn't flushed down the drain), energy savings are achieved since the water that is pumped back to the water heater is generally warmer than city water. In addition, since the pump gets water to the fixture more quickly, there is an overall reduction of hot water use.
DHW Tank Insulation	Domestic water heating	Pre-cut tank jackets/blankets (DHW tank insulation) are readily available and can be installed on hot water storage tanks to reduce standby heat losses. Caution is required to install blankets on gas water heaters, to avoid blocking the flue, the air intake to the burner, or the drain at the bottom. The thermostat should also remain uncovered.
Draft Proofing Kit	Space heating	Using a kit with: - Spray Foam (1 can), coverage of 61' @ 1/64" wide crack - Caulk (1 tube), coverage of 14' @1/4" yield/tube - Foam tape (approx. 30 ft.), 1/16" crack, for example for an attic hatch, door perimeters, and casement windows - Energy Saver Gasket with 2 child safety inserts (4 sets), assuming 1 square inch crack associated with the electrical outlet
Early Furnace Replacement - 60% AFUE -	Space heating	Replace an old convention furnace early with a condensing model 90+% annual fuel utilization efficiency (AFUE) Furnace

Residential Measure Name	End Use	Measure Description
90% AFUE Furnace		
Electric Air-Source Cold Climate Heat Pumps	Space heating	This measure assesses the installation of air source heat pumps (ASHP) to replace existing heating systems. In operation, the ASHP is used until the outdoor temperature falls below the heat pump's balance point. At this point, the heat pump shuts off and heating is provided by backup forced-air heating system. Recent advances in cold climate heat pumps allow some models to operate in temperatures approaching -20°C. The energy used by a particular heat pump over the course of the heating season is given by its heating seasonal performance factor (HSPF), which varies by region since heat pumps operate less efficiently in colder climates.
Electric Ground-Source Heat Pumps	Space heating	Ground source heat pumps (GSHP) use the thermal storage capacity of the ground for space heating and cooling and/or domestic water heating applications. Closed loop GSHP systems employ horizontal or vertical piping networks placed below the ground as heat exchangers (heat source/sink). Water is pumped through the network and exchanges heat with the heat pump's refrigerant.
ENERGY STAR® Home	Space heating and domestic water heating	For new construction, this is an upgrade from an EnerGuide 83 home to an EnerGuide 85 home.
Faucet Aerator	Domestic water heating	The measure consists of installing either 1.0 or 1.5 GPM aerators on bathroom and kitchen faucets in residential dwellings. The magnitude of the site specific savings is heavily dependent upon human behavior and will vary significantly between sites. The savings algorithm and the resulting deemed savings values are based on data and assumptions representing typical consumption patterns, inlet and outlet water temperatures, flow rates, and water heating equipment efficiencies. These factors are taken from studies that have been previously completed.
Fireplace intermittent ignition control retrofit	Fireplace	Retrofitting a fireplace with an intermittent ignition control. Gas savings were based on gas normally consumed by a pilot flame during the winter and the non-heating season discounted by the fraction of people who shut off their fireplace gas pilot in the non-heating season according to the NRCAN SHEU study.

Residential Measure Name	End Use	Measure Description
Heat Reflector Panels	Space heating	For older hydronically (hot water) heated homes, one of the simplest ways to reduce space heating costs is to reduce the amount of heat being absorbed by surrounding walls. Installing heat reflector panels behind radiators can have a noticeable impact on a residence's space heating energy consumption. The savings that can be achieved are attractive since this measure is relatively inexpensive and easy to Implement. A heat reflector panel, attached to the wall behind radiators, reflects heat back into the room that would usually absorbed by the wall. Also, the air trapped behind the radiator prevents conductive heat loss to the exterior.
High Efficiency Condensing Furnace	Space heating	Condensing gas furnaces achieve savings through the utilization of a sealed, super insulated combustion chamber, more efficient burners, and multiple heat exchangers that remove a significant portion of the waste heat from the flue gasses. As the heat exchangers remove waste heat from the flue gases, the gases condense and the resulting condensate must be drained. This measure is for a high efficiency condensing furnace with a regular Permanent Split Capacitance (PSC) motor at can achieve an annual fuel utilization efficiency (AFUE) of 96%.
High Efficiency Fireplace with Pilotless Ignition	Fireplace	A new high efficiency fireplace with intermittent (pilotless) ignition - Freestanding fireplace: 70% EnerGuide Rating (Minimum) - Insert: 60% EnerGuide Rating (Minimum) - Zero Clearance >= 40 kBtu/h: 60% EnerGuide Rating (Minimum) - Zero Clearance < 40 kBtu/h: 70% EnerGuide Rating (Minimum) The savings is based on: 1. A 5-percentage point efficiency increase above the median model efficiency according to the EnerGuide Rating 2. Pilotless (intermittent) ignition (i.e. gas saved from the standing pilot burner)
High Efficiency Gas Storage Water Heater	Domestic water heating	This measure is for the installation of a new high efficiency gas storage water heater in the case of residential new construction. This measure focuses on high efficiency gas storage water heaters that have efficiencies above the basic code requirements (new construction projects or time of natural replacement) in a residential setting.
High-Efficiency (ENERGY STAR®) Clothes Washers	Domestic water heating and dryer	The measure is an upgrade from a standard washer that meets the Ontario Regulation for appliance and product energy efficiency to an ENERGY STAR® certified washer.
High-Efficiency (ENERGY	Domestic water heating	ENERGY STAR® dishwashers save energy by using improved technology for the primary wash cycle and by using less hot water to clean. Features include more effective washing action, energy efficient motors, and sensors that determine the length of

Residential Measure Name	End Use	Measure Description
STAR®) Dishwashers		the wash cycle and the temperature of the water necessary to clean the dishes. In addition, some advanced dishwashers can sense and adjust for the amount of soil on dishes, using only as much water as necessary. These savings affect both the energy used for heating the water and the mechanical energy of the dishwasher.
High-Efficiency Gas Clothes Dryers	Dryer	The major distinction with energy efficient gas clothes dryer models is that they incorporate termination controls to sense dryness and turn off automatically. The most efficient models have moisture sensors in the drum for sensing dryness, while other lower-cost and slightly less efficient models infer dryness by sensing the temperature of the exhaust air. The majority of the retail models currently available employ some type of dryness sensing technology but it is unclear how often these controls are used by homeowners. ENERGY STAR® certified dryers use 20 percent less energy than conventional models.
High-Efficiency Gas-Fired Pool Heaters	Pool heating	High-efficiency pool heaters incorporate advanced heat exchangers, forced draft combustion systems, pilot-less ignitions and innovations in hydraulics, which results in performance efficiencies that range between 90% and 95%, compared to efficiencies of 80% to 85% for standard models.
High-Efficiency Heat Recovery Ventilators (HRVs)	Space heating	Heat recovery ventilators (HRVs) are heat exchangers that are integrated into the centralized ventilation and exhaust systems of many newer homes. In the winter, they allow for incoming fresh air to be heated by outgoing stale air. Conversely, in homes with central air conditioning systems, they allow incoming fresh air to be cooled by outgoing stale air in the summer. High efficiency HRVs incorporate more effective heat exchangers. Some models also include desiccant wheels so that latent heat (i.e. humidity) can be transferred between the two air streams.
Insulating Pool Covers	Pool heating	Between 30% and 50% of the heat loss from a swimming pool is due to evaporation. In an outdoor pool, this heat loss either adds to the cost of heating the pool or shortens the swimming season. Evaporation also increases the quantity of chemicals that must be added to the pool. A pool cover can reduce evaporation and other heat losses but can also reduce heat gains depending on the design. An insulating vinyl pool cover is assumed for this analysis. Although substantially more expensive than the bubble type covers, insulating vinyl pool covers are much more robust and, thus, have much longer lifetimes. They are also more effective at trapping heat.

Residential Measure Name	End Use	Measure Description
Integrated Heating and DHW (Forced Air Heating)	Space heating and domestic water heating	Integrated mechanical systems combine the most efficient technologies for residential space heating and domestic water heating into one package. For example, the Matrix system by NTI NY Thermal incorporates a condensing furnace, condensing boiler, condensing water heater and HRV all in one unit. Primary benefits of the integrated units include compact construction, lower cost of installation (only one set of gas, water and circulation connections are required), and lower installation and maintenance costs (once the technology is mature). Since the minimum performance standards for furnaces was brought up to 90% efficiency at the end of 2009, the base case system is a 90% efficient forced-air furnace and a standard efficiency natural gas tank-style water heater. With this baseline, the integrated system would offer little in the way of space heating savings, but it does still offer DHW savings because the integrated system would heat domestic water with its high-efficiency, condensing combustion.
Integrated Heating and DHW (Hydronic Heating)	Space heating and domestic water heating	Integrated mechanical systems combine the most efficient technologies for residential space heating and domestic water heating into one package. For example, the Matrix system by NTI NY Thermal incorporates a condensing furnace, condensing boiler, condensing water heater and HRV all in one unit. Primary benefits of the integrated units include compact construction, lower cost of installation (only one set of gas, water and circulation connections are required), and lower installation and maintenance costs (once the technology is mature). Water heating in the base case is assumed to be provided by a standard efficiency natural gas tank-style water heater (efficiency factor of 0.62 or 0.64), while space heating is provided by a non-condensing boiler, assumed to have an annual fuel utilization efficiency (AFUE) of 82%. The HRV in the base case is assumed to be of similar efficiency to that in the integrated unit.
Low-Flow Shower Head	Domestic water heating	Hot water heating represents a large share of the energy consumption in homes. One of the simplest ways to reduce hot water heating costs is to reduce the amount of hot water use. Installing low flow showerheads can have a noticeable impact on a residence's hot water consumption. The savings that can be achieved are attractive since this measure is relatively inexpensive and easy to implement. Low flow showerheads restrict the flow of the water while maintaining the water pressure.
Maintain Weather-stripping	Space heating	Homeowner air leakage sealing does not include a blower door test to quantify leakage levels and to identify the location of air leaks. Homeowners are likely to identify leakage primarily in more visible areas of the envelope, for example, the major leakage at window-to-wall interfaces, around doors (especially

Residential Measure Name	End Use	Measure Description
		patio doors), through electrical and plumbing penetrations and perhaps at the top of foundation walls. Installation of weather stripping, sealant and gaskets are the most likely methods to be used. Less visible sources of air leaks such as pot lights, wall-to-floor interfaces (i.e., top and bottom of baseboards), bathroom and kitchen exhaust piping, and leaks from the top of walls into the attic are less likely to be addressed by the homeowner.
Minimize Hot and Warm Wash	Domestic water heating	Heating water can account for up to 90% of the energy consumption of clothes washers. Reducing the number of hot and warm water wash cycles decreases the energy required to heat water, irrespective of the clothes washer used.
Net-Zero Ready Energy Homes	Space heating and domestic water heating	Net-zero energy homes (NZEH) produce at least as much energy as they consume. The energy consumption of a NZEH is significantly lower than average due to the addition of a wide array of energy efficiency features. Measures that are typically considered include increased insulation, super high-performance windows, ENERGY STAR® appliances, solar thermal space and/or water heating, heat pumps, and passive solar designs. In addition, NZE Homes incorporate on-site power generation, such as solar PV panels or small wind turbines, to offset electrical loads; this on-site power equipment has not been included in this measure.
Pipe Wrap	Domestic water heating	This measure provides the gas savings estimate and costs of insulating hot water pipes for conventional gas hot water storage tanks. Natural gas savings are calculated using an engineering algorithm. For example, it uses the linear heat loss formulae with R values rather than the more complex radial heat loss formulae with less familiar conductivity (k) values. It also holds the water temperature constant throughout the pipe length and over time, uses a marginal improvement as the basis for savings, and uses a single factor to account for space heating system interactive effects.
Professional Air Sealing/Weather Stripping/Caulkin g	Space heating	Air leakage sealing of building envelopes includes completion of a blower door test to quantify leakage levels and to identify the location of air leaks. Generally, major leakage occurs at window-to-wall interfaces, around doors (especially patio doors), through electrical and plumbing penetrations and at the top of foundation walls. Installation of sealant and gaskets are generally accepted methods for reducing air leakage in buildings. Other sources of air leaks include pot lights, wall-to-floor interfaces (i.e., top and bottom of baseboards) and bathroom and kitchen exhaust piping.
Programmable Thermostat	Space heating	Residential home heating and cooling system thermostats maintain temperature in the spaces by either turning equipment on and off as necessary or modulating the systems to address the heating and cooling loads. Setting the temperatures back

Residential Measure Name	End Use	Measure Description
		when residences are unoccupied or the residents are sleeping presents a significant potential for savings, as it reduces heat loss and allows the heating and cooling systems to operate for shorter periods of time.
Reduce Temperature of DHW	Domestic water heating	Lowering DHW heater temperature results in energy savings from the reduction of standby losses and consumption. Higher temperatures use more energy and increase the risk of scaling; for this reason a temperature of 45°C is suggested by some health authorities. At the same time, temperatures below 60°C can increase the risk of promoting legionellae bacteria. The actual ideal temperature setpoint is an active topic of debate. For this reason, this measure only considers a temperature reduction in tanks with setpoints above 60°C.
Slab Insulation (Unfinished Basements)	Space heating	Insulation can be added both under and on top of basement slab floors. However, in existing homes, only the latter is practical. It is assumed that additional insulation is added to the slab floor while the basement is being finished. This can be done by purchasing insulated subfloor panels or laying down extruded polystyrene rigid foam insulation.
Social Benchmarking and Home Energy Monitoring	Space heating and domestic water heating	Energy social benchmarking is the review of a household's energy consumption and the comparison of its performance with its energy history and that of other similar households. Home energy monitoring systems provide the information about a household's electricity use, which can be either real-time or historic, needed for benchmarking. Real-time consumption information, tracking over time, and comparisons with other households can encourage customers to reduce energy consumption.
Solar Pool Heaters	Pool heating	Installing a solar thermal system for pool heating. In a solar thermal system, water is circulated through solar collectors which absorb solar energy that is transferred to the water for heating.
Solar Pre-Heated Make-Up Air Systems (e.g., SolarWall®)	Space heating	Solar preheated ventilation systems preheat incoming ventilation air and reduce heat loss through the portion of the building shell covered by them. They consist of perforated steel or aluminum absorber sheets that are mounted vertically on a building’s exterior surface and are ideally mounted on southerly facing walls, plus or minus 20 degrees. The dark coloured metal sheets that make up the system are mounted a small distance away from the building’s surface, creating an air cavity. A negative pressure is created within the cavity by ventilation fans and air is drawn through small holes in the metal panels. On sunny winter days, these systems can raise incoming air temperatures by 25°C to 35°C. In summer months, ventilation air can be drawn directly from the outside through a bypass damper, while heated air is rejected through vents at the top of the air

Residential Measure Name	End Use	Measure Description
		cavity. These systems are generally used in commercial and industrial applications but they have seen some limited residential use.
Super High-Performance Windows	Space heating	In addition to low-E coating, argon fill and insulating spacers, super-high performance windows incorporate features such as triple glazing, transparent insulating films, and fibreglass frames.
Tankless Water Heaters	Domestic water heating	The measure consists of the installation of natural gas tankless water heaters for domestic hot water production in residential buildings. Natural gas tankless water heaters are available in both condensing and non-condensing models. Tankless, also called instantaneous or on-demand, water heaters provide hot water without using a storage tank. There is nominal “storage”, ranging from 2-10 gallons within the heat exchanger, but this represents 5% or less of the storage tank capacity associated with equivalent storage water heaters. The reduced storage capacity results in the need for higher capacity burners to generate the flow of hot water necessary to serve equivalent peak loads.
Temperature Setback (During Day)	Space heating	Lowering the thermostat temperature when away from the home can save energy without reducing comfort. This measure is easiest to implement with a programmable thermostat, but setbacks can be done manually as well.
Temperature Setback (Overnight)	Space heating	Lowering the thermostat temperature when asleep can save up to as much as 1% for each degree for an eight hour setback without reducing comfort. This measure is easiest to implement with a programmable thermostat, but setbacks can be done manually as well.
Use Clothes Line for Drying	Dryer	Switching to passive methods of clothes drying, such as clothes lines during summer months and indoor drying racks, is an effective way of reducing energy consumption at little-to-no cost.
Use Sensor for Clothes Dryer	Dryer	Most--and soon to be all--clothes dryers include moisture sensors that automatically shut off the dryer when the clothes are dry. This feature saves energy and increases the life of clothes by preventing over-drying. This moisture sensing feature is not always used when drying clothes.
Wall Insulation	Space heating	It can be challenging to retrofit wall insulation in existing homes since the inside surfaces of the exterior walls are already finished. It is sometimes possible to add insulation to a wall by blowing insulating materials into the wall cavity, if sufficient space exists. Alternatively, if the siding is old and due for replacement, rigid foam insulation can be added before the new siding is installed. In this situation, it would also be quite cost-effective to

Residential Measure Name	End Use	Measure Description
		install a more effective vapour and air barrier (e.g., Dupont Tyvek®) to reduce the amount of air leakage through the walls.
Wastewater Heat Recovery Systems	Domestic water heating	Residential wastewater heat recovery systems transfer the waste heat from drains to preheat make-up water. These systems work well only for DHW uses in which the hot water use and the draining of wastewater are simultaneous. Thus, in homes, application to anything other than showers is difficult. Heat recovery systems incorporate shell-and-tube heat exchangers that typically have efficiencies in the range of 40% to 55%, depending on factors such as design, material, overall length, and fluid flow rate.
Zoned-Up Windows: (ENERGY STAR®) Rating for a Colder Zone	Space heating	High-performance windows incorporate a number of additional energy-saving features, including low-E (soft coating), insulating spacers, argon fill and low conductivity frames (which can be sliders, hinged or picture). These windows are certified based on their energy rating (ER), which is based on their tested energy performance, rather than on their specific combination of features. In this case, however, the ENERGY STAR® windows for a colder zone are specified instead of the ENERGY STAR® windows for the zone where the house is located - for example, Zone C ENERGY STAR® windows would be chosen for a house in Zone A. High-performance windows also provide occupant co-benefits, such as reduced interior noise, reduced air leakage, greater thermal comfort, and fewer condensation problems.

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Commercial Measure Name	End Use	Measure Description
Adaptive Thermostats	Space Heating	Space heating and cooling system thermostats maintain temperature in the spaces by either turning equipment on and off as necessary or modulating the systems to address the heating and cooling loads. This measure is for the installation of an adaptive thermostat in place of non-programmable thermostats or a traditional programmable thermostat that is being operated in manual model. Natural gas savings are achieved due to the heating system having to heat at a lower temperature during unoccupied building hours.
Advanced BAS/Controllers	Multiple	Advanced building automation systems (BAS) are able to automatically detect anomalies in building operations and can automate building diagnostics as well. These systems typically take data on how energy systems are performing in a building, analyze them using logic and physical modeling to detect deviations from expected performance and use built-in logic to suggest the cause of the deviation. In addition, advanced BAS have improved predictive, self-tuning control algorithms that help to minimize the need for bypass or override of the BAS. Energy savings generally result from re-instituting equipment scheduling, expanded control to lighting and VAV boxes, instituting integrated control strategies and improving self-tuning diagnostics.
Air Curtains	Space Heating	Air curtains are typically mounted above doorways and separate indoor and outdoor environments with a stream of air strategically engineered to strike the floor with a particular velocity and position. There are no code standards that require air curtains in Ontario. The primary energy impact associated with the installation of air curtains is a reduction in natural gas usage or electricity resulting from reduced infiltration of cold air or hot air that needs to be heated or cooled when it enters a building.
Boilers - Advanced Controls	Space Heating	An alternative to complex linkage designs, modern burners are increasingly using servomotors with parallel positioning to independently control the quantities of fuel and air delivered to the burner head. Controls without linkages allow for easy tune-ups and minor adjustments, while eliminating hysteresis, or lack of re-traceability, and provide accurate point-to-point control. These controls provide consistent performance and repeatability as the burner adjusts to different firing rates. Variable frequency drives (VFDs) can also be used to more accurately control the air supply.

Commercial Measure Name	End Use	Measure Description
Boilers - Blowdown Heat Recovery	Space Heating	The boiler blowdown process involves the periodic or continuous removal of water from a boiler to remove accumulated dissolved solids and/or sludge. During the process, water is discharged from the boiler to avoid the negative impacts of dissolved solids or impurities on boiler efficiency and maintenance. However, boiler blowdown wastes energy because the blowdown liquid is at about the same temperature as the steam produced. Much of this heat can be recovered by routing the blow down liquid through a heat exchanger that preheats the boiler's make-up water. The recovered heat can be used to preheat boiler make-up water before it enters the deaerator, and for low-pressure steam to heat water inside the deaerator, which reduces the cost to run the deaerator and improves overall boiler efficiency.
Boilers - Combustion Air Preheat	Space Heating	Combustion air preheaters are similar to economizers in that they transfer energy from the flue gases back into the system. In these devices, however, the energy is transferred to the incoming combustion air. The efficiency benefit is roughly 1% for every 40°F increase in the combustion air temperature. Changes in combustion air temperature directly affect the amount of combustion air supplied to the boiler and may increase or decrease the excess air.
Boilers - Feedwater Economizers	Space Heating	Recovered boiler exhaust heat (or process heat) can be a good source of energy to preheat heater make-up water. Waste heat can be captured from a clean waste stream that normally goes into the atmosphere or down the drain and used to heat the make-up water before it is sent to the water-heater. Implementation of many potential opportunities is restricted due to factors such as the distance between the process and the water-heater, the available heat in the in the process stream, the volume of the process stream and the consistency of the heat generation.
Boilers - High Efficiency Burners	Space Heating	Due to differing temperature requirements and applications, a wide variety of burners are available. Burner technology is also continuously improving. Efficient burner technology generally recovers heat from the flue gas and includes recuperative and regenerative style burners. These burners are more efficient at higher-temperature applications. Advancements over the past five years include the commercialization of self-recuperative and self-regenerative burners that use staged combustion to achieve flameless combustion. This results in more uniform heating, lower peak flame temperatures, improved efficiency and lower NO_x emissions.

Commercial Measure Name	End Use	Measure Description
Building Recommissioning (Standard)	Multiple	Improvements that can be made by ensuring that existing systems are optimised to meet current occupant needs. Undertaken by existing facility staff and contractors (controls, boilers, etc.) that are responsible for daily operation of the building. Focus on low cost/no cost measures. Measures could include (but are not limited to): • Controls optimization (scheduling, temperature setback, etc.) • Restore automatic control • Replace/repair/recalibrate sensors • Relocate sensors • Reduce valve and damper leakage • Add/replace/repair dampers and actuators • Eliminate simultaneous heating and cooling • Optimize outdoor air flow rates • Optimize economizer usage • Add/optimize chiller staging • Add/optimize boiler staging • Add/optimize chilled water supply temperature reset • Add/optimize hot water supply temperature reset
Building Recommissioning (Enhanced)	Multiple	Improvements that can be made by ensuring that existing systems are optimised to meet current occupant needs. Undertaken by existing facility staff and contractors (controls, boilers, etc.) that are responsible for daily operation of the building in collaboration with a third party recommissioning provider who leads the process. Measures will potentially have a greater capital expenditure than standard retrocommissioning (RCx). Measures are similar to standard RCx but more comprehensive and leverage the experience of third party contractors more knowledgeable of the RCx process in close collaboration with facility staff and contractors who are knowledgeable of the day to day operation and historical issues of the facility.
CEE Tier 2 Clothes Washers	Water Heating	Consortium for Energy Efficiency (CEE) Tier 2 Front-Loading Clothes Washers have a greater tub capacity than regular clothes washers which allows the user to wash fewer loads. They also use faster spin speeds to extract more water from clothes, reducing dryer time and energy use. The water factor (number of gallons needed for each cubic foot of laundry) is lower for CEE Tier 2 clothes washers than ENERGY STAR® standards, making them even more efficient than ENERGY STAR® rated washers.

Commercial Measure Name	End Use	Measure Description
Commercial Ozone Laundry Treatment	Water Heating	In the commercial laundry industry, ozone is generated via a corona discharge or an ultraviolet light. The ozone dissolves in water temperatures ranging from cold to ambient, and activates the detergents, improving their activity and leading to stronger cleaning capabilities. This measure is for installing an ozone system on a commercial clothes washer. There is no distinction between the retrofit and new construction project types for this measure, as the applicable assumptions are the same. The primary savings produced by installing an ozone treatment system are hot water savings from reduced cycles and more efficient cleaning. Natural gas is saved from the reduced hot water demand, in addition to water savings.
Condensing Boilers	Space Heating	Condensing boilers feature additional advanced heat exchanger designs and materials that extract more heat from the flue gases before they are exhausted. The temperature of the flue gases is reduced to the point where the water vapour produced during combustion condenses back into liquid form, releasing the latent heat, which improves energy efficiency.
Condensing Boilers	Water Heating	Condensing boilers feature additional advanced heat exchanger designs and materials that extract more heat from the flue gases before they are exhausted. The temperature of the flue gases is reduced to the point where the water vapour produced during combustion condenses back into liquid form, releasing the latent heat, which improves energy efficiency.
Condensing Make-Up Air Units	Space Heating	The measure is for the installation of natural gas condensing make-up air (MUA) units with a thermal efficiency of 90% or higher in commercial buildings. The measure is for the installation of condensing make-up air units which have efficiencies that are higher than code requires. Commercial make-up air units are performance rated by their thermal efficiency. The primary energy impact associated with the installation of condensing make-up air unit in this service territory is a reduction in natural gas usage resulting from the unit's improved efficiency. No water consumption impacts are associated with this measure.
Condensing Storage Water Heaters	Water Heating	The measure consists of the installation of natural gas fueled condensing storage water heaters for hot water production in commercial facilities. Non-condensing storage water heaters are not eligible under this measure. This measure provides incentives for installing natural gas condensing storage water heaters in commercial facilities for either the new construction or time of natural replacement measure category. Natural gas savings are achieved as a result of the higher overall average thermal efficiency of the condensing storage units. No water consumption impacts are associated with this measure.

Commercial Measure Name	End Use	Measure Description
Condensing Tankless Water Heaters	Water Heating	Tankless, also called instantaneous or on-demand, water heaters provide hot water without using a storage tank. This measure provides incentives for installing tankless natural gas water heaters in commercial facilities for either the new construction or time of natural replacement measure category. The baseline technology for this measure is a non-condensing natural gas fueled storage water heater providing the service hot water needs for all or portions of commercial facilities. Natural gas savings are achieved as a result of the higher overall average thermal efficiency of the condensing tankless units and elimination of storage or standby losses. There are no electric or water consumption impacts associated with this measure.
Condensing Unit Heaters	Space Heating	The measure is for the installation of a condensing unit heater in commercial facilities. The measure covers the installation of condensing unit heaters in commercial settings. The primary energy impact associated with the installation of condensing boilers in this service territory is a reduction in natural gas usage resulting from the furnace's improved efficiency. No water consumption impacts are associated with this measure.
Demand Control Kitchen Ventilation	Space Heating	Commercial Kitchen Ventilation (CKV) systems exhaust smoke, flue gases, heat and cooking odors. This measure applies to existing constant volume commercial kitchen exhaust hoods with rated capacity of not more than 15,000 CFM. The reduction in the requirement for make-up air results in natural gas savings during the heating season and electric energy savings during the cooling season.
Demand Control Ventilation	Space Heating	Adequate ventilation of buildings is necessary to remove "pollutants" resulting from activities occurring within the space and maintain acceptable levels of indoor air quality. This measure pertains to the implementation of demand control ventilation (DCV) based on CO_2 concentrations within the space, for single-zone, constant volume ventilation systems. The primary energy impact associated with implementation of DCV in this service territory is lower heating fuel consumption resulting from a reduction in the quantity of outside air introduced to the space during the heating season.
Demand Controlled Ventilation (Enhanced)	Space Heating	Demand controlled ventilation (DCV) measure applied to a broader scope of facilities than the current prescriptive program offering from Enbridge Gas Distribution and Union Gas

Commercial Measure Name	End Use	Measure Description
Destratification Fans	Space Heating	This following measure covers the use of ceiling mounted paddle destratification fans with a minimum diameter of 20 feet, in commercial space heating applications. The energy efficient case is a space with destratification fans. Natural gas savings are achieved due to the difference in heat loss through the roof before and after destratification.
Drain Water Heat Recovery (DWHR)	Water Heating	Drain Water Heat Recovery (DWHR) pre-heats incoming domestic cold water with the available drain water heat that would otherwise be lost. A storage tank and pumping equipment is needed for batch-style (i.e., front load or top load) Laundry equipment to ensure cold water flows into the DWHR system and warm drain water flows out concurrently.
Electric Air-Source Cold Climate Heat Pumps	Space Heating	Cold climate or low temperature air source heat pump (ASHP) systems are more efficient, utilizing the vapour compression cycle to transfer heat from the outside to inside or vice versa depending on the season.
Electric Ground-Source Heat Pumps	Space Heating	Ground source heat pump (GSHP) systems are more efficient than conventional heat pump systems, with higher COPs and EERs. GSHPs also replace the need for a boiler in winter by utilizing heat stored in the ground; this heat is upgraded by a vapour-compressor refrigeration cycle. In summer, heat from a building is rejected to the ground, eliminating the need for a cooling tower or a heat rejecter. They also lower operating costs because the ground is cooler than the outdoor air. Water-to-air heat pumps are typically installed throughout a building with duct work serving only the immediate zone; a two-pipe water distribution system conveys water to and from the ground source heat exchanger. The heat exchanger field consists of a grid of vertical boreholes with plastic u-tube heat exchangers connected in parallel.
Energy Recovery Ventilation	Space Heating	An energy recovery ventilator (ERV) refers to heat exchanger equipment that is designed to transfer heat and moisture between the building exhaust air and the outside supply air. The performance of the ERV can be quantified by its total effectiveness, which is a function of both its sensible and latent effectiveness. The measure covers the installation of energy recovery ventilators in commercial settings. Natural gas savings are achieved because the supply air arrives at the building heating equipment at a higher enthalpy than it would without an ERV. This means that less energy is required to heat the supply air to the set point temperature.
Energy Recovery Ventilation (Enhanced)	Space Heating	Energy recovery ventilation (ERV) measure applied to a broader scope of facilities than the current prescriptive program offering from Enbridge Gas Distribution and Union Gas

Commercial Measure Name	End Use	Measure Description
ENERGY STAR® Clothes Washer	Water Heating	ENERGY STAR® Clothes Washers have a greater tub capacity than regular clothes washers which allows the user to wash fewer loads. They also use faster spin speeds to extract more water from clothes, reducing dryer time and energy use. The water use factor is lower than that of the federal standard.
ENERGY STAR® Convection Ovens	Cooking	Convection ovens are used in commercial and institutional food service preparation as an alternative to conventional ovens. This measure applies to the installation of a full size ENERGY STAR® qualifying convection oven in commercial and industrial food processing settings. The savings are achieved through reduced cooking time and lower idle energy rate.
ENERGY STAR® Dishwashers	Water Heating	Dishwasher types are broken into two primary categories: high temperature and low temperature. High temperature dishwashers have the additional benefits of shorter wash cycles and less water use per cycle. Low temperature dishwashers require chemical sanitizers and may require multiple cycles to clean hard to remove residues. Installing ENERGY STAR® rated dishwashers will result in Natural gas and electrical savings are achieved due to the fact that the higher efficiency equipment requires less heated water and typically less electricity for each load than its baseline non-ENERGY STAR® counterpart. The washing efficiency and energy savings are primarily derived from the reduced use of hot water. This measure provides incentives for installing ENERGY STAR® dishwashers in a commercial setting.
ENERGY STAR® Fryers	Cooking	Fryers are used in commercial and institutional food service preparation for frying food in heated oil. This measure applies to ENERGY STAR® qualifying open-vat fryers in commercial and institutional food processing settings. ENERGY STAR® fryers are up to 30% more efficient than non-ENERGY STAR® fryers. ENERGY STAR® fryers save energy by offering shorter cook times and higher production rates through advanced burner and heat exchanger designs.
ENERGY STAR® Griddles	Cooking	This measure covers ENERGY STAR® griddles meeting a minimum cooking efficiency of 38% (gas) and a normalized idle energy rate of 2,600 Btu/h/ft.^{2}. Commercial griddles that have earned the ENERGY STAR® are about 10 percent more energy efficient than standard models.

Commercial Measure Name	End Use	Measure Description
ENERGY STAR® Steam Cookers	Cooking	Steam cookers are used in commercial and institutional food service preparation to cook foods that do not need to form a crust. This measure is for ENERGY STAR® approved steam cookers with either connectionless or steam-generator design. These steamer designs are often termed “boilerless.” Standard boiler steamers are not eligible as they do not meet ENERGY STAR® efficiency criteria due to their low efficiencies during idling and cooking. Energy efficient steam cookers that have earned the ENERGY STAR® designation offer shorter cook times, higher production rates, and reduced heat loss due to better insulation and more efficient steam delivery system.
Gas Fired Rooftop Units (Two-Stage)	Space Heating	This measure involves replacing a single-stage unit with a two-stage rooftop unit. A two stage rooftop unit uses a two stage gas valve which takes a partially open position upon a call for one stage heating and opens fully if there is a call for both stages. This saves energy by consuming less natural gas when temperatures are slightly above setpoints.
Green Roofs	Space Heating	This measure covers green or living roofs, which are roofs of buildings that are partially or completely covered with vegetation. The typical application for a vegetation filled roof system is a flat or low slope roof. The soil and vegetation reduces surface temperatures of the roof and provides a natural cooling effect for the building.
Heat Recovery Ventilation	Space Heating	A heat recovery ventilator (HRV) refers to heat exchanger equipment that is designed to transfer sensible heat from the building exhaust air to the outside supply air. This measure is intended for buildings in commercial settings with an existing HRV, or a new construction building that requires a heat recovery system. The performance of the HRV can be quantified by its sensible effectiveness, which is defined as the ratio of actual heat energy captured to the maximum heat energy that could be captured. Heat is recovered from the outgoing exhaust air and added to the incoming supply air. Natural gas savings are achieved because the incoming supply air arrives at the building heating equipment at a higher temperature than it would without an HRV.
Heat Reflector Panels	Space Heating	A saw tooth panel made of clear polyvinyl chloride (PVC) with a reflective surface placed behind a radiator, thereby reducing heat lost to poorly insulated exterior walls.
High Efficiency Boilers	Space Heating	This measure applies to high efficiency non-condensing boilers with an annual fuel utilization efficiency (AFUE) of 85-88% compared to the baseline technology of non-condensing boilers with an AFUE of 80-82%.

Commercial Measure Name	End Use	Measure Description
High Efficiency Boilers	Water Heating	This measure applies to high efficiency hydronic boilers with combustion efficiency levels of 85-88% compared to the base technology boilers with 80-82% combustion efficiency.
High Efficiency Underfired Broilers	Cooking	Under-fired broilers (often referred to as "charbroilers") are used in commercial and institutional food service to do a range of tasks that range from melting cheese to cooking large cuts of meat. Under-fired broilers consume natural gas when they are pre-heating and cooking. The broiler is typically left on during all operating hours so that the broiler is instantly available for cooking. The primary energy impact associated with the installation of a high efficiency underfired broiler is a reduction in natural gas required during the pre-heat and cook/idle modes.
High-Performance Glazing	Space Heating	High-performance glazings refer to a variety of technologies that can be used alone or in combination to provide an array of benefits, including lower energy costs, enhanced daylighting opportunities, reduced heating and cooling loads, and more comfortable spaces. They incorporate one or more of the following: • Double or triple glazing with a sealed insulating glass unit • Low-E glass • Inert gas such as argon or krypton in the sealed unit • Low conductivity or "warm edge" spacer bars • Insulated frames and sashes. When used, these features will create windows with U-values of 0.32 Btu/hr.ft^2.ºF or lower.
Indirect Water Heater	Water Heating	An indirect water heater uses the main furnace or boiler to heat a fluid that's circulated through a heat exchanger in the storage tank. The indirect tank is usually plumbed to be a separate "zone" or circuit on the heating system. They are part of what's called an integrated or combination water and space heating systems.
Infrared Heaters	Space Heating	Natural gas fired infrared (IR) heaters use radiant tube emitters or ceramic/steel emitters (high intensity) as the body by which to transmit infrared energy and heat. The measure covers the installation of infrared heaters in commercial settings. Natural gas savings are achieved as objects are directly heated instead of the air around them; there is less air stratification for more uniform heating of the space; usage of smaller fans and less stratification which reduces air infiltration changes; and there are minor electricity savings because of the smaller fans in IR heaters compared to equally sized unit heaters or the blowers in forced hot air systems.

Commercial Measure Name	End Use	Measure Description
Keep Doors Closed	Space Heating	Open doors allow conditioned air (both heated and cooled) to escape from the building. Changing this behaviour is likely most effective with buildings with large doors such as warehouses, buildings with loading bays and garages. However, to a lesser extent it is also applicable to buildings such as retail stores where customers are entering and exiting the building frequently.
Low-Flow Showerheads	Water Heating	Low flow showerheads restrict the flow of the water while maintaining the water pressure. This measure pertains to the implementation of low-flow showerheads in multi-residential households. The primary energy impact associated with implementation of low-flow showerheads is a reduction in natural gas resulting from a reduction in the hot water consumption.
New Construction - 25% Better	Multiple	High-performance new building construction refers to new high-efficiency buildings that are designed using the integrated design process. Through the application and integration of energy efficiency technologies and design approaches, high-efficiency buildings that use this process can achieve substantial improvements over conventional new buildings. The co-benefits include lower operations and maintenance costs, and enhanced occupant productivity and health.
New Construction - 40% Better	Multiple	High-performance new building construction refers to new high-efficiency buildings that are designed using the integrated design process. Through the application and integration of energy efficiency technologies and design approaches, high-efficiency buildings that use this process can achieve substantial improvements over conventional new buildings. The co-benefits include lower operations and maintenance costs, and enhanced occupant productivity and health.
Operations and Maintenance (O&M) Improvements	Multiple	Improvements that can be made through improved O&M practices and low cost measures by properly trained internal or external O&M staff. Measures could include (but are not limited to): • Air sealing (weather-stripping) • Insulating steam and hot water pipes • Insulating steam traps, valves, etc. with removable jackets • Cleaning heat exchangers (air coils, etc.) Measures are cheaper and simpler to implement than retrocommissioning measures and are frequently part of the routine maintenance procedures of a well-run facility.
Pizza/Bakery Oven Insulation	Cooking	Oven insulation blankets reduce heat loss when cooking and lower the air conditioning load required to cool the building and room.

Commercial Measure Name	End Use	Measure Description
Pre-Rinse Spray Nozzles	Water Heating	Pre-rinse spray nozzles (PRSNs) are commonly utilized in commercial kitchens to remove food waste from dishes and cookware prior to cleaning in the dishwasher, using a pressurized flow of hot water. This measure provides incentives for installing low-flow PRSNs, designed to provide sustained levels of performance with reduced flow of hot water. The primary energy impact associated with the installation of low–flow PRSN is natural gas savings associated with a reduction in hot-water consumption. There are associated water cost impacts.
Refrigeration Waste Heat Recovery	Space Heating	Recovery of waste heat from refrigeration compressors to offset space heating energy. Measure based on Enbridge Gas Distribution and Union Gas Custom Retrofit Incentive databases.
Roof Insulation	Space Heating	Upgrading insulation on a built-up roofing system typically involves adding additional layers of rigid insulation at the time of re-reroofing.
Solar Preheat Makeup Air	Space Heating	Solar walls consist of cladding placed on a southern exposure of a building to preheat ventilation air, usually for 100% outdoor air applications such as a warehouse.
Solar Water Preheat (DHW)	Water Heating	Solar water preheat is the most efficient renewable technology currently on the market, avoiding the need to convert sunlight to electricity but instead converting directly to heat. Solar thermal systems preheat makeup water to an intermediate temperature, reducing the operation of the standard hot water heater.
Solar Water Preheat (Pools)	Other	Solar water preheat is the most efficient renewable technology currently on the market, avoiding the need to convert sunlight to electricity but instead converting directly to heat. Solar thermal systems preheat makeup water to an intermediate temperature, reducing the operation of the standard hot water heater. This measure applies specifically to solar water preheating for indoor swimming pools.
Super-High Efficiency Furnaces	Space Heating	The measure is for the installation of high efficiency condensing furnaces with an annual fuel utilization efficiency (AFUE) of 95% or higher in commercial buildings. The measure is for the installation of condensing furnaces which have efficiencies that exceed code requirements. The primary energy impact associated with the installation of condensing furnaces in this service territory is a reduction in natural gas usage resulting from the furnace's improved efficiency.
Use Shades/Blinds	Space Heating	This behaviour is targeted at office workers who work near windows and have control of blinds and is intended to encourage employees to open the blinds during cold weather to allow solar gains to help heat the office buildings

Commercial Measure Name	End Use	Measure Description
Ventilation Fan VFDs	Space Heating	Installation of variable frequency drives on ventilation fans. Measure based on Enbridge Gas Distribution and Union Gas Custom Retrofit Incentive databases.
Wall Insulation	Space Heating	Various insulating materials and methods can be used to upgrade wall insulation, including applying rigid polystyrene board to the exterior of a building or installing fiberglass batts between interior wall studs. In addition to superior insulating performance and lower energy costs, the co-benefits include enhanced comfort, noise reduction and reduced HVAC equipment costs.

Industrial

Industrial Measure Name	End Use	Measure Description
Advanced Boiler Controls	Steam and Hot Water Systems	An alternative to complex linkage designs, modern burners are increasingly using servomotors with parallel positioning to independently control the quantities of fuel and air delivered to the burner head. Controls without linkages allow for easy tune-ups and minor adjustments, while eliminating hysteresis, or lack of re-traceability, and provide accurate point-to-point control. These controls provide consistent performance and repeatability as the burner adjusts to different firing rates. Variable frequency drives can also be used to more accurately control the air supply. Other technologies included in combustion controls are metered control, cross limited control and oxygen and carbon monoxide trim controls. Advanced boiler controls are generally one of the first energy efficiency measures a facility will implement to improve boiler energy efficiency.
Advanced Heating and Process Controls	Direct Heating	Advanced heating and process controls refer to opportunities to reduce energy losses by improving control systems that govern aspects such as material handling, heat storage, and turndown. These also include process thermal optimization measures. Energy losses that are generally attributable to system operation during periods of low throughput are addressed. Some advanced controls use a programmed heating temperature setting for part load operation.
Air Compressor Heat Recovery	Heating and Ventilation	Heat recovered from air cooled compressors can be used for other purposes (e.g., for space heating during the winter). In most cases, a simple duct system can direct the heated air into the building during the winter and to out of the building during the summer.
Asphalt and Cement Manufacturing Process Improvements	Direct Heating	Process improvements specific to the asphalt and cement industry include: ▪ Stock pile slope improvements and paving ▪ High efficiency roller mills ▪ High efficiency classifiers ▪ Optimized fuel preparation for roller mills ▪ Reduced moisture levels in product ▪ Blended cement products
Automated Blowdown Control	Steam and Hot Water Systems &	Boiler water must be blown down periodically to prevent scale from forming on boiler tubes. This process can be wasteful if too much water is lost to blowdown. Automatic blowdown controls measure and respond to boiler water conductivity and acidity to ensure that only the right amount of blowdown water is used. Although automatic blowdown control is becoming a

Industrial Measure Name	End Use	Measure Description
	CHP Steam	standard practice for new boilers, a large percentage of existing boilers do not have automated control.
Automated Temperature Control	Heating and Ventilation	Automatic temperature controls allow the temperature in different zones to be varied according to a schedule in order to save energy during unoccupied periods. These controls may also prevent individuals from manually changing the temperature settings to suboptimal set-points. Reducing the amount of energy consumed for space conditioning during unoccupied periods can provide energy savings with no capital investment.
Blowdown Heat Recovery	Steam and Hot Water Systems & CHP Steam	The boiler blowdown process involves the periodic or continuous removal of water from a boiler to remove accumulated dissolved solids and/or sludge. During the process, water is discharged from the boiler to avoid the negative impacts of dissolved solids or impurities on boiler efficiency and maintenance. However, boiler blowdown wastes energy because the blowdown liquid is at about the same temperature as the steam produced. Much of this heat can be recovered by routing the blow down liquid through a heat exchanger that preheats the boiler's make-up water before it enters the deaerator, thus reducing the cost to run the deaerator and improving the overall efficiency of the boiler.
Boiler Combustion Air Preheat	Steam and Hot Water Systems & CHP Steam	Combustion air preheaters are similar to economizers in that they transfer energy from the flue gases back into the system. In these devices, however, the energy is transferred to the incoming combustion air. The efficiency benefit is roughly 1% for every 40°F increase in the combustion air temperature. Changes in combustion air temperature directly affect the amount of combustion air supplied to the boiler and may increase or decrease the excess air.
Boiler Right Sizing and Load Management	Steam and Hot Water Systems	An oversized boiler will turn on and off more often than a boiler that has been properly matched to the demand, which may result in short-cycling losses. If the boiler is instead left on standby, short-cycling losses will be avoided but energy will be wasted in keeping the boiler on standby. Rather than sizing a boiler to meet the highest possible load, fuel savings can be achieved by adding a smaller boiler sized to meet the plant's average loads, or by using multiple small boilers. Multiple small boilers offer reliability and flexibility to operators to follow load swings without over-firing and short cycling. Load management also helps to reduce load variation. As this measure is normally an end-of-life option there should be no incremental costs to right size a boiler and it may be financially beneficial to purchase a smaller boiler.

Industrial Measure Name	End Use	Measure Description
Boiler Tune Up	Steam and Hot Water Systems & CHP Steam	A preventative boiler maintenance program, including optimizing the air-to-fuel ratio, burner maintenance, and tube cleaning, can save about 2% of a facility's total energy use with an average simple payback of five months. Periodic measurement of flue gas oxygen, carbon monoxide, opacity and temperature provides the fundamental data required for a boiler tune-up. A typical tune-up might include a reduction of excess air (and thereby excess oxygen, O_2), boiler tube cleaning and recalibration of boiler controls. A comprehensive tune-up with precision testing equipment to detect and correct excess air losses, smoking, unburned fuel losses, sooting and high stack temperatures, can result in boiler fuel savings as high as 20%, while typical savings are approximately 8% of boiler fuel usage. Boiler maintenance programs are a relatively common practice, especially for large boilers and in energy-intensive industries.
Burn Digester Gas in Boilers	Steam and Hot Water Systems & CHP Steam	Because digester gas typically contains much higher levels of non-combustible gases, it has a lower heating value than natural gas. Therefore, this measure requires the fuel train and burner to be modified such that the boiler can achieve the same heating output by accommodating a higher overall gas flow rate. Boilers can operate with either digester gas entirely or co-fired with other fuels. Characteristics of digester gas can vary depending on the source but typical chemical breakdowns result in half the heating value of natural gas. Digester gas is heavier than natural gas and is typically supplied at a lower pressure than natural gas. These facts create the need for a system that can handle high flow rates of gas with minimum pressure drop.
Chemical Manufacturing Process Improvements	Steam and Hot Water Systems	Chemical manufacturing is a broad sub-sector which involves thermal processes that are both energy intensive and complex. Depending on the process, there can be a wide range of process-specific improvements available to improve energy performance. Such improvements could include upgrading column internals, avoiding over-purifying products, advanced distillation processes, distillation column flooding predictors, improved catalysts, and a wide range of other process upgrades and energy saving opportunities.

Industrial Measure Name	End Use	Measure Description
Condensate Return	Steam and Hot Water Systems & CHP Steam	The primary purpose of an effective condensate recovery system is to make the most effective use of all remaining steam and condensate energy after process use. Maximizing the amount of condensate that is returned to the boiler can save both energy and water treatment chemicals. The value of the condensate varies with its pressure and temperature, which depends on the operating pressure of the steam system. If the boiler feedwater is 15°C, and the condensate is 100°C, then each kilogram of condensate contains 419 kJ; if the boiler is operating at 80% efficiency, then it represents 523 kJ. Condensate under pressure and above 100°C can be flashed to steam for additional energy value/recovery. The feasibility of returning condensate to the boiler depends on the distance the condensate needs to be piped to the boiler, and the volume of the condensate. Longer distances and smaller volumes negatively affect the feasibility of returning the condensate.
Condensing Boiler	Steam and Hot water Systems	High efficiency condensing boilers feature advanced heat exchanger designs and materials that extract more heat from the flue gases before they are exhausted. The temperature of the flue gases is reduced to the point where the water vapour produced during combustion condenses back into liquid form, releasing the latent heat, which improves energy efficiency. Modern condensing boilers have energy efficiencies of 90% to 96%, compared with new conventional non-condensing models with energy efficiencies up to 85%. Many boilers over 20 years old typically operate at overall water-to-steam boiler efficiencies of less than 70%, making them good candidates for upgrading or replacement. A number of natural gas-fired condensing boilers are available, but very few oil-burning models are on the market. The installation of new boilers generally only occurs when existing boilers reach the end of their service life or during plant expansion.
Condensing Economizers	Steam and Hot water Systems	Condensing economizers reduce flue gas temperature below its dew point, resulting in improved heat recovery. Boilers equipped with condensing economizers can have an overall efficiency that exceeds 90%. Indirect contact condensing economizers remove heat from flue gases by passing them through shell-and-tube or tubular heat exchangers. Direct contact condensing economizers consist of a vapour-conditioning chamber followed by a countercurrent spray chamber. For larger boilers, economizers can cost from \$200 to \$600 per million Btu/hr. of boiler capacity. In the case of smaller boilers, the cost can exceed \$1,000 per million Btu/hr. of boiler

Industrial Measure Name	End Use	Measure Description
		capacity. Prices can range from a few thousand dollars for the smaller units up to over $100,000 for the larger boiler economizers. Installation costs vary widely, but will be higher for situations where it is necessary to move piping and equipment to make room for the economizer. In some cases, the installation cost can equal the equipment cost. Nearly all larger applications have economizers, such as power boilers for utilities, petrochemical plants, and high-pressure steam applications.
Destratification Fans	Heating and Ventilation	Destratification fans are high-volume, low-speed fans designed to counter stratification in large spaces. The air temperature in large, high ceiling storage rooms can become stratified, meaning that the air is layered at different temperatures at different levels. Destratification is the process by which the air is mixed using fans to eliminate the stratified layers of temperature. These fans use a comparable amount of energy to conventional ceiling fans but fewer are required, reducing the total energy required.
Direct Contact Water Heaters	Steam and Hot water Systems	In direct contact hot water heaters, the combustion gas comes in direct contact with the water, therefore eliminating any performance reductions caused by the fouling of heat exchange surfaces or heat losses through the heat transfer medium. However, the efficiency of direct contact water heaters can be greatly reduced by high return fluid temperatures. Direct contact hot water heaters are most often installed when an existing water heater needs to be replaced due to its age and associated increased maintenance requirements. The market penetration of the technology is relatively small and a significant potential exists to increase the market penetration.
Exhaust Gas Heat Recovery	Direct Heating	Exhaust gas heat recovery increases efficiency by extracting energy from flue gases and recycling it back to the process. Significant efficiency improvements can be made on furnaces, kilns, dryers and ovens, even if they are already operating with properly tuned ratio and temperature controls. For low and medium temperature applications, heat recovered from flue gases can be used to preheat oven burners, or to heat other media such as feed product or ventilation make-up air. Heat or enthalpy wheels are used at a number of facilities to recover heat. The energy saved by the heat recovered from the flue gas is related to the temperature difference between the flue gas and the heated medium, and the savings depend upon finding applications where heat recovery is economic and improves the process. For high-temperature applications there are four widely used methods: direct heat recovery to the product/feed stream;

Industrial Measure Name	End Use	Measure Description
		indirect heat recovery through the use of a recuperator; thermal energy storage for future use; and use of a waste heat boiler.
Fabricated Metal Manufacturing Process Improvements	Direct Heating	Process improvements specific to the fabricated metal industry include: ▪ Annealing / metal treating optimization ▪ Higher efficiency process-specific equipment
Feedwater Economizers	Steam and Hot Water Systems	Recovered boiler exhaust heat (or process heat) can be a good source of energy to preheat heater make-up water. Waste heat can be captured from a clean waste stream that normally goes into the atmosphere or down the drain and used to heat the make-up water before it is sent to the water-heater. Implementation of many potential opportunities is restricted due to factors such as the distance between the process and the water-heater, the available heat in the in the process stream, the volume of the process stream and the consistency of the heat generation.
Food and Beverage Manufacturing Process Improvements	Direct Heating	Opportunities that exist specifically in the food and beverage manufacturing sector include: ▪ Line speed improvements ▪ Efficient conveying equipment ▪ Wort cooler optimization ▪ Fire suppression upgrades
Greenhouse Curtains	Heating and Ventilation	Many greenhouses experience peak energy consumption at night. Movable insulated curtains can be used to minimize nighttime heat loss. Semi-porous aluminized materials cut heat loss by up to 65% and can also be used to provide summer shade and condensation drainage.
Greenhouse Envelope Improvements	Heating and Ventilation	Infrared film should be installed on the inside of a greenhouse with anti-condensate-treated film on the outside. This combination reduces space heating energy use by 10-20% without condensation problems. Sidewalls should be well insulated using 1"-2" foam insulation board or spray-on foam insulation. Just 2" of foam insulation around the knee wall of a 28' x 100' greenhouse can save 558 therms of natural gas annually if the greenhouse is heated throughout the year.
Greenhouses Other Energy Efficiency Upgrades	Steam and Hot Water Systems	Energy savings can be achieved by insulating all of the heating pipes and by installing an indoor water storage tank to reduce temperature fluctuations within the greenhouse.
High Efficiency Burners	Direct Heating	Due to differing temperature requirements and the wide range of boiler models, a variety of burners are available and burner

Industrial Measure Name	End Use	Measure Description
	& Steam and Hot Water Systems	technology is continuously improving. Improvement in boiler burner efficiency is mainly associated with optimum combustion efficiency and improving the heat profile inside the combustion chamber. The efficiency of boiler burners is closely linked with the boiler controls regulating the fuel-to-air ratio. For example, inefficient fuel-to-air ratio control will reduce the efficiency of the burner.
High Efficiency Furnaces	Direct Heating	One of the most effective ways to increase the efficiency of a furnace is to preheat the combustion air through a recuperator or a regenerator. Recuperators are heat exchangers placed on the furnace stack that recover heat from the exhaust gas in order to preheat the incoming combustion air, while keeping the two gas streams from mixing. Regenerators consist of two or more separate heat storage sections, where each section alternatively allows the passage of either flue gas or combustion air, thereby intermittently heating and cooling each heat storage section. Considerable efforts have been undertaken to develop new industry-specific technologies for improving the efficiency of furnaces. For example, smelting reduction processes have been developed as a more environmentally friendly alternative to the conventional blast furnace that is used for steelmaking. Due to the different reaction conditions and the full integration, the theoretical energy demand of smelt reduction is lower than that of a blast furnace. Previous studies estimate the energy consumption to be 20-30% lower than that of the conventional blast furnace route. Smelt reduction plants generally have a higher coal input per tonne product than current blast furnaces, but export larger quantities of fuel gas.
High Efficiency Heating Units	Heating and Ventilation	High efficiency gas heaters reduce natural gas consumption while maintaining heating performance by increasing the natural gas combustion efficiency, reducing off-cycle heating losses, and/or transferring the latent heat of flue gases to the building space. By using strategies such as intermittent ignition devices, separated combustion, power venting, condensing heat exchangers, or direct-fired combustion, high-efficiency gas heaters offer increased steady-state thermal efficiency over conventional unit heaters. This measure focuses on high efficiency packaged heating options, such as the Cambridge Heater, and is complemented by a separate measure covering the opportunity for savings through radiant heaters.
High Efficiency Ovens & Dryers	Direct Heating	Infrared (IR) ovens are an example of high-efficiency ovens and use less energy than convection ovens because they heat

Industrial Measure Name	End Use	Measure Description
		the parts directly. Unlike convection ovens, they do not heat the air. IR ovens may also be used as a booster oven where final curing requires convection heating. Production rates may increase significantly when an IR oven replaces a convection oven. IR ovens can either replace existing convection ovens or be an addition to an existing one. Premium efficiency air dryers are of the refrigerated type with dew point control. These dryers are typically at least 15% more efficient than regenerative desiccant dryers, which are still commonly used in industry.
Improved Building Envelope	Heating and Ventilation	The building envelope plays an important role in regulating interior temperatures and helps determine the amount of energy required to maintain thermal comfort. Heat transfer through the building envelope can be minimized by improving insulation and air sealing, particularly in walls and roofs. Cracks and leaks can generally be sealed with caulk, spray foam, or weather stripping. There are a variety of insulation options, including concrete block, insulating concrete forms, blanket, spray foam, rigid foam, and natural fiber. It is important to consider the R-value of the insulation (ability to resist heat flow) - the higher the R-value the better the thermal performance of the insulation.
Insulation	Direct Heating & Steam and Hot Water Systems & CHP Steam	Insulation increases the amount of energy available for end uses by decreasing the amount of heat lost from the distribution system. Insulation removed during maintenance is often not replaced, and older insulation deteriorates with time. To improve the energy efficiency of the system, regular insulation surveys assist in identifying areas with insufficient insulation.
Minimize Deaerator Vent Losses	Steam and Hot Water Systems & CHP Steam	A deaerator works to remove dissolved oxygen from boiler feedwater and must vent this oxygen, and any other non-condensable gases that were removed, into the atmosphere. Typically, a very small percentage of steam is also vented alongside these non-condensable gases. The amount of steam vented should be minimized through proper operation and controls. If the deaerator is operated at very high pressures, this may cause excessive venting of steam to the atmosphere. Instead, the deaerator tank should be operated to meet water

Industrial Measure Name	End Use	Measure Description
		chemistry requirements for oxygen and carbon dioxide rather than simply using pressure and temperature as a guide. This measure has been implemented on a relatively limited scale.
Minimize Door Openings	Heating and Ventilation	A large amount of heat may be lost between the time loading dock doors are opened and when a truck is docked. Having an air curtain at the loading dock door lowers the amount of energy lost through the opening by acting as a thermal barrier. Air curtains work by generating a jet of high-velocity air that separates the two sides of the jet, forming a screen or curtain. The air curtain should be activated as soon as the loading dock door is opened and then stopped once it is closed in order to conserve energy when the air curtain is not required. Air curtains can be heated or unheated, depending on the application requirement. Other ways to reduce the time loading dock doors are opened include the installation of high speed doors (a.k.a. zip doors or rapid doors). High speed doors open and close rapidly (with an opening rate of at least 32 in/sec and a closing rate of at least 24 in/sec) to contain temperatures and reduce wait times. They require less maintenance than conventional doors and are engineered for a longer service life. High-speed doors have an automatic closing device and are most efficient when cycled 55 or more times per day.
Mining Process Improvements	Direct Heating	Uncast air heat recovery systems, ice stopes, heat exchange areas, or combinations of these technologies could eliminate natural gas consumption in underground air heating. Ice stope technology involves pumping warm water from mine depth to preheat mine ventilation air in winter.
Non-Metallic Mineral Product Manufacturing Process Improvements	Direct Heating	Opportunities that exist specific to the non-metallic mineral product manufacturing sector include: ▪ Increase use of cullet ▪ Oxy-fuel furnaces with cullet pre-heating ▪ Inclusion of fly-ash instead of clay and shale
Optimize Combustion	Direct Heating	Combustion efficiency can be improved by adjusting the air-to-fuel ratio to reduce excess air as too much excess air carries away excessive amounts of heat.
Primary Metal Manufacturing Process Improvements	Direct Heating	Opportunities that exist specific to the primary metal manufacturing sector include: ▪ Process flow optimization ▪ Gas injection technology to improve heat transfer to the melt ▪ Ladle preheating ▪ Flare and O_2 reduction in steelmaking ▪ Techniques to minimize slag formation ▪ Top gas recovery turbines

Industrial Measure Name	End Use	Measure Description
Process Heat Recovery	Direct Heating	Recovered process heat can be a good source of energy to preheat heater make-up water. Waste heat can be captured from a clean waste stream that normally goes into the atmosphere or down the drain and used to heat the make-up water before it is sent to the water-heater. Implementation of many potential opportunities is restricted due to factors such as the distance between the process and the water-heater, the available heat in the in the process stream, the volume of the process stream and the consistency of the heat generation. Implementation of the measure is not widely practiced, especially in small- and medium-sized facilities. Consequently, a significant potential remains.
Process Improvements (changing cleaning chemicals, set points, exhaust, moisture control, etc.)	Direct Heating	Advanced heating and process controls refer to opportunities to reduce energy losses by improving control systems that govern aspects such as material handling, heat storage and turndown. These also include process thermal optimization measures. Energy losses that are generally attributable to system operation during periods of low throughput are addressed. Some advanced controls use a programmed heating temperature setting for part load operation; they also monitor and control exhaust gas oxygen as well as unburned hydrocarbon and carbon monoxide emissions.
Pulp and Paper Process Improvements	Steam and Hot Water Systems	Pulp and paper facilities contain many process specific opportunities for energy performance improvement. These can include improvements to liquor heating, biomass combustion, and various process upgrades to reduce steam consumption. The savings available at a given facility can vary significantly, based on the age of equipment and the level of improvements that have already been made.
Radiant Heaters	Heating and Ventilation	Radiant heating equipment is designed to provide comfort heating through the application of radiant heat transfer. Radiant heaters work by emitting infrared light, which is absorbed by surrounding objects such as floors, equipment, or people. Infrared light is minimally absorbed by the ambient air, although the air immediately surrounding the “heated” objects is warmed by the increased temperatures of those objects. These systems are very efficient compared to convection heaters, and therefore consume significantly less natural gas than a convection heating system.
Reduce Boiler Steam Pressure	Steam and Hot Water Systems	Steam pressure reduction is the lowering of the steam pressure at the boiler plant by means of the pressure setting on the boiler plant control. Steam pressure reduction mainly affects the high pressure part of the steam system. Within practical limits, pressure-reducing valves will adjust the pressure at lower levels to the previous set-points. This means

Industrial Measure Name	End Use	Measure Description
		that most of the savings benefits from pressure reduction occurs in the high pressure section of the steam system. This measure most commonly applies to oversized steam systems. Pressure reduction should be monitored and maintained regularly.
Reduced Furnace Openings (Air & Chain Curtains)	Direct Heating	Air heat seals at continuous oven and dryer entrances and exits limit heat loss with airflow. Air curtains are generally not applicable to batch operations. Air curtains are not usually technically feasible for high-temperature processes such as kilns and furnaces due to the process layout and the high-temperature differential. In a typical application, a heat seal draws hot interior air and compresses it in scroll fans. Centrifugal fans are used to create an air curtain at oven and dryer openings. When used on oven/dryer openings, air curtains are normally installed horizontally over the opening and angled slightly inward to contain the hot air. Air heat seals can be installed as a retrofit or a new installation.
Refining Process Improvements	Direct Heating	A wide variety of catalysts are used for different refinery processes (cracking, reforming, hydro-treating, etc.), each with their own performance characteristics, and different potentials to be improved upon. Catalyst developments often focus on improving plant yield, but they also achieve greater energy efficiency by reducing the required levels of recycle, heating, and recompression energy. A 2013 chemical industry roadmap noted that constant improvement in catalytic processes is essential to reduce energy consumption in refineries.
Regenerative Thermal Oxidizers	Direct Heating	A regenerative thermal oxidizer (RTO) is an industrial process for the treatment of exhaust air. The system is a type of thermal oxidizer that uses a bed of ceramic material to absorb heat from the exhaust gas. Once oxidized in the combustion chamber, the hot purified air releases thermal energy as it passes through the media bed in the direction of the outlet flow. The outlet bed is heated and the gas is cooled so that the outlet gas temperature is only slightly higher than the process inlet temperature. Poppet valves alternate the airflow direction into the media beds to maximize energy recovery within the oxidizer. The high energy recovery within these oxidizers reduces the auxiliary fuel requirement and saves operating cost of the RTO unit. The energy recovery can save up to 95% of auxiliary fuel requirements.
Solar Walls	Heating and Ventilation	Independent monitoring data indicates that SolarWall® systems can displace between 20-50% of heating fuel consumption, depending on size and application. The SolarWall® technology delivers one of the verifiably fastest

Industrial Measure Name	End Use	Measure Description
		solar paybacks. The system uses solar energy to pre-heat ventilation air and substantially reduces traditional heating fuel expenses in a building integrated system which requires no maintenance and has a 30+ year lifespan.
Steam Leak Repairs	Steam and Hot Water Systems & CHP Steam	Leaks in steam lines allow steam to escape, resulting in higher steam production requirements from the boiler to meet the system needs. Leaks most often occur at the fittings in steam pipe systems. Energy savings depend on the boiler efficiency, hours of operation, boiler operating pressure, and the energy content of the steam and feedwater.
Steam Trap Survey and Repair	Steam and Hot Water Systems & CHP Steam	Steam traps are important to the performance of both end use equipment and the distribution system. Traps provide for condensate removal with little or no steam loss. If the traps do not function properly, excess steam will flow through the end use device or the condensate will back up into it. Excess steam loss will lead to costly operation while condensate backup will promote poor performance and may lead to water hammer. Traps can also remove non-condensable gases that reduce heat exchanger effectiveness. Regular steam trap surveys are an important measure to identify faulty steam traps and steam leaks. Repairing the steam leaks and faulty steam traps will minimize steam losses and improve system efficiency.
Transportation and Machinery Manufacturing Process Improvements	Direct Heating	Vehicle bodies and other machine parts often undergo cleaning, priming, painting, and drying processes through paint lines/booths. Ovens with conveyor lines are often used to for drying processes, and line speed improvements can yield significant energy savings. For example, reducing breakdowns and optimizing auto shutdowns can ensure that the ovens are only in operation when necessary.
Ventilation Heat Recovery	Heating and Ventilation	Two types of heat recovery technologies are included in the measure: BKM reverse flow heat recovery system and heat wheels. A BKM reverse flow heat recovery system is an air-to-air heat exchanger that collects the thermal energy in air that is exhausted from a facility and uses it to preheat the fresh make-up air brought in. These units use two heat sinks, which are alternately used to either heat the incoming air or cool the exhaust air and switch roles every 70 seconds. An enthalpy wheel or heat wheel is a type of energy recovery ventilator that uses a rotating energy exchanger in the form of a cylinder. The cylinder is packed with a heat transfer medium that allows for many small air passages, or flutes, that run

Industrial Measure Name	End Use	Measure Description
		parallel to the direction of airflow. In a typical installation, the wheel is positioned in a duct system such that it is divided into two half-moon sections. Stale air from the conditioned space is exhausted through one half, while outdoor air is drawn through the other half in a counter flow pattern. At the same time, the wheel is rotated slowly. Sensible heat is transferred as the metallic substrate picks up and stores heat from the hot air stream before having the heat removed by the cold air stream. Latent heat is transferred as the medium condenses moisture from the air stream that has the higher humidity ratio.
Ventilation Optimization	Heating and Ventilation	Optimized ventilation ensures ventilation is adequate for the application and minimizes the amount of energy required to heat make-up air. Optimized ventilation generally includes any of the following elements: ▪ Minimize make-up air and exhaust flow rates to necessary flow rates. Besides ensuring the optimum flow rate, this element also addresses the time of use. For example, when ventilation is required for a specific process, then the ventilation is only in operation when the process is in operation, and the volume of ventilation is designed to be sufficient for the process requirements. ▪ Balance make-up and exhaust flow rates to minimize negative or positive air pressure in the working space. ▪ Includes redesign and/or control measures to optimize the ventilation flow rates to be sufficient for the needs within the space. Control systems may also include carbon monoxide monitoring to ensure ventilation is sufficient to maintain required air quality. This reduces the instances of either over-ventilating or under-ventilating the space. ▪ Optimal distribution of air ensures adequate ventilation in all the spaces and minimizes over-ventilation in some areas, while other areas might experience insufficient ventilation.
Warehouse Loading Dock Seals	Heating and Ventilation	Warehouse loading dock seals provide a barrier between the back of a docked truck and the edges of the loading opening. An improper seal may result in drafts and a loss of heat from the warehouse.

Appendix C Input Assumption Adjustments

Sector	Measure	Summary of Modifications
Commercial	Condensing Boilers	The savings for these measures were modified for two reasons: 1) to account for upcoming changes to minimum energy performance standards (MEPS) for larger capacity (>300 MBH) boilers that are scheduled to take effect on Jan. 1, 2017; and 2) to account for the seasonal efficiencies of both the baseline and upgrade boilers rather than their thermal efficiencies. Although the upcoming changes to boiler MEPS reduced the savings potential slightly, these modifications resulted in significantly higher savings for these measures overall. However, these savings estimates are based on ICF's experience and are more consistent with savings being claimed in custom applications of these measures.
Commercial	High Efficiency Boilers	
Commercial	Energy Recovery Ventilation	The savings for this measure were modified to reflect the fact that the installation of energy recovery ventilators (ERVs) rather than heat recovery ventilators (HRVs) typically results in incremental savings.
Residential	ENERGY STAR® for New Homes	The measure should be an improvement from the Ontario Building Code requirements that came into effect in 2016. Therefore, the baseline should be roughly 15% better than EnerGuide 80. The measure from Union Gas' 2012 - 2014 DSM plan does not meet the minimum code requirements and, therefore, the measure upgrade was changed to EnerGuide 85 and the baseline was changed to EnerGuide 83.

Appendix D Program Budgets

Constrained Budget Derivation

The 2015-2020 constrained budget was derived from actual spend from Enbridge Gas Distribution and Union Gas' 2015 program year, plus the 2016-2020 DSM budgets from th

Both Union Gas and Enbridge Gas Distribution provide combined Commercial and Industrial programs. These commercial and industrial program budgets were split by ICF based on relative 2014 gas consumption amounts.

Timeframe	Unit	Residential Sector			Commercial / Industrial			Total Program Budget	Overhead	Total Including Overhead
		Excluding Low Income	Single-Family Low Income	Multi-family Low Income	Commercial	Industrial	Large Volume			
2015	Enbridge 2015 Actual Spend ($)	$ 11,515,558	$ 4,444,616	$ 2,111,746	9,278,894			$ 27,350,814	$ 7,869,781	$ 35,220,595
	Union 2015 2015 Actual Spend ($)	$ 6,855,550	$ 5,635,259	$ 2,065,776	11,368,397		$ 3,209,716	$ 29,134,698	$ 3,044,068	$ 32,178,766
2016-2020	Enbridge 2016-2020 Budget ($)	$ 107,936,839	$ 31,915,867	$ 24,968,616	98,262,785			$ 263,084,107	$ 57,944,090	$ 321,028,197
	Union 2016-2020 Budget ($)	$ 57,996,000	$ 42,550,000	$ 15,598,000	92,452,000		$ 15,750,000	$ 224,346,000	$ 81,936,066	$ 306,282,066
2015-2020	Enbridge and Union Total ($)	$ 184,303,947	$ 84,545,742	$ 44,744,138	211,362,076		$ 18,959,716	$ 543,915,619	$ 150,794,005	$ 694,709,624
	Overhead distributed by proportion of program budget	$ 51,096,033	$ 23,439,281	$ 12,404,769	$ 58,597,571		$ 5,256,351		$ 150,794,005	
	Total including overheads	$ 235,399,980	$ 107,985,023	$ 57,148,907	$ 269,959,647		$ 24,216,067			$ 694,709,624
	2014 Consumption (m3) of Commercial and Industrial Sectors				6,706,467,798	4,850,650,645				
	Proportion of consumption by Commercial / Industrial				58%	42%				
	Final budgets for programs/sectors	**$ 235,399,980**	**$ 107,985,023**	**$ 57,148,907**	**$ 156,654,592**	**$ 113,305,054**	**$ 24,216,067**			**$ 694,709,624**

The 2021-2030 constrained budget was derived by multiplying the budgets for 2016-2020 5-year period by two.

Timeframe	Unit	Residential Sector			Commercial / Industrial			Total Program Budget	Overhead	Total Including Overhead
		Excluding Low Income	Single-Family Low Income	Multi-family Low Income	Commercial	Industrial	Large Volume			
2016-2020	Enbridge 2016-2020 Budget ($)	$ 107,936,839	$ 31,915,867	$ 24,968,616	$ 98,262,785			$ 263,084,107	$ 57,944,090	$ 526,168,214
	Overhead distributed by proportion of program budget	$ 23,773,013	$ 7,029,447	$ 5,499,320	$ 21,642,309				$ 57,944,090	
	Union 2016-2020 Budget ($)	$ 57,996,000	$ 42,550,000	$ 15,598,000	$ 92,452,000		$ 15,750,000			$ 224,346,000
	Overhead distributed by proportion of program budget	$ 21,181,408	$ 15,540,191	$ 5,696,731	$ 33,765,493		$ 5,752,244		$ 81,936,066	
	Total including overheads	$ 210,887,260	$ 97,035,505	$ 51,762,667	$ 246,122,587		$ 21,502,244			$ 627,310,263
2021-2030	Total including overheads	$ 421,774,520	$ 194,071,010	$ 103,525,334	$ 492,245,174		$ 43,004,489			$ 1,254,620,526
	Proportion of consumption by Commercial / Industrial				58%	42%				
	Final budgets for programs/sectors	**$ 421,774,520**	**$ 194,071,010**	**$ 103,525,334**	**$ 285,644,421**	**$ 206,600,753**	**$ 43,004,489**			**$ 1,254,620,526**

Notes:

Union Gas did not provide separate budgets for low-income residential and multi-family programs in 2015, so the low-income budget was apportioned according to the relative size of those two programs in 2016-2020

Enbridge Gas Distribution does not offer DSM programs for its large volume customers.

Overhead was distributed according to what proportion the program made up of the total program budget.

Semi Constrained Budget Derivation

The 2015-2020 Semi-constrained budget was derived from actual spend from Enbridge and Union's 2015 program year, plus the 2016-2020 DSM budgets from the DSM Decision.
As per the semi-constrained scenario, 2016 and 2017 budgets are the same as the constrained potential, 2018 is 4/3 x 2016-2020 annual budget, 2019 is 5/3 x 2016-2020 annual budget, 2020 is twice the 2016-2020 annual budget. The results is that the 2016-2020 semi-constrained program budget is 1.4 times the total constrained 2016-2020 budget (plus 2015).

Timeframe	Unit	Residential Sector		Commercial / Industrial				Total Program Budget	Overhead	Total Including Overhead
		Excluding Low Income	Single-Family Low Income	Multi-family Low Income	Commercial	Industrial	Large Volume			
2015	Enbridge 2015 Actual Spend ($)	$ 11,515,558	$ 4,444,616	$ 2,111,746	9,278,894			$ 27,350,814	$ 7,869,781	$ 35,220,595
	Union 2015 2015 Actual Spend ($)	$ 6,855,550	$ 5,635,259	$ 2,065,776	11,368,397		$ 3,209,716	$ 29,134,698	$ 3,044,068	$ 32,178,766
2016-2020	Enbridge 2016-2020 Budget ($) x 1.4	$ 151,111,575	$ 44,682,214	$ 34,956,062	137,567,899			$ 368,317,750	$ 81,121,726	$ 449,439,476
	Union 2016-2020 Budget ($) x 1.4	$ 81,194,400	$ 59,570,000	$ 21,837,200	129,432,800		$ 22,050,000	$ 314,084,400	$114,710,493	$ 428,794,893
2015-2020	Enbridge and Union Total ($)	$ 250,677,083	$ 114,332,089	$ 60,970,784	$ 287,647,990		$ 25,259,716	$ 738,887,662	$206,746,068	$ 945,633,730
	Overhead distributed by proportion of program budget	$ 66,965,901	$ 33,465,150	$ 16,497,931.69	$ 81,428,582.82		$ 8,388,502		$206,746,068	
	Total including overheads	$ 317,642,984	$ 147,797,239	$ 77,468,716	$ 369,076,573		$ 33,648,218			$ 945,633,730
	2014 Consumption (m3) of Commercial and Industrial Sectors				6,706,467,798	4,850,650,645				
	Proportion of consumption by Commercial / Industrial				58%	42%				
	Final budgets for programs/sectors	**$ 317,642,984**	**$ 147,797,239**	**$ 77,468,716**	**$ 214,171,046**	**$ 154,905,526**	**$ 33,648,218**			**$ 945,633,730**

The 2021-2030 semi-constrained budget was derived by doubling the 2021-2030 constrained budget.

Timeframe	Unit	Residential Sector		Commercial / Industrial				Total Program Budget	Overhead	Total Including Overhead
		Excluding Low Income	Single-Family Low Income	Multi-family Low Income	Commercial	Industrial	Large Volume			
2021-2030	**Final budgets for programs/sectors**	**$ 843,549,039**	**$ 388,142,020**	**$ 207,050,668**	**$ 571,288,842**	**$ 413,201,506**	**$ 86,008,978**			**$2,509,241,053**

Notes:
Union did not provide separate budgets for low-income residential and multi-family programs in 2015, so the low-income budget was apportioned according to the relative size of those two programs in 2016-2020
Enbridge does not offer DSM programs for its large volume customers.
Overhead was distributed according to what proportion the program made up of the total program budget.

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