March 27, 2015

Ms. Kirsten Walli
Board Secretary
Ontario Energy Board
2300 Yonge St., 27th Floor
Toronto, ON M4P 1E4

Dear Ms. Walli:

Re: **EB-2014-0354 – New and Updated DSM Measures**
Joint Submission from Union Gas Limited and Enbridge Gas Distribution Inc.

Union Gas Limited ("Union") and Enbridge Gas Distribution Inc. ("Enbridge") request the approval of the Ontario Energy Board (the "Board") for the new and updated DSM measures.

In the DSM Guidelines for Natural Gas Utilities (EB-2008-0346), the Board directed the utilities to make an annual application to update approved input assumptions and encouraged the utilities to file a joint application.

This application is a follow up to the letter filed by the utilities on December 10, 2014, stating that an application for the approval of 2014 DSM input assumptions would be filed in the first quarter of 2015. Per the Joint Terms of Reference on Stakeholder Engagement for DSM Activities by Union and Enbridge dated November 4, 2011, one of the Technical Evaluation Committee's ("TEC") major tasks is the development of a Technical Reference Manual for natural gas DSM activities. Currently in development, the Technical Reference Manual is envisioned to replace the common Table of Measure Assumptions and Substantiation Documents filed by the utilities with their 2012 to 2014 Plans.

Until such time as the Technical Reference Manual is completed in its entirety, and filed with the Board, the common Table of Measure Assumptions and Substantiation Documents will continue to document the Board approved measure assumptions.

This joint application is made in consultation with the TEC, to update the common Table of Measure Assumptions and Substantiation Documents. With respect to this update the TEC endorsement speaks only to the following measure assumptions:

- New Measures:
    - Residential High Efficiency Water Heaters
    - Commercial Demand Control Ventilation – New Construction and Retrofit
- Updated Measures:
    - Residential and Low Income Faucet Aerators (Bathroom & Kitchen)
    - Residential and Low Income Pipe Wrap
    - Commercial Energy Star Fryers
    - Commercial Energy Star Convection Ovens
    - Commercial Energy Star Steam Cookers

  - Commercial High Efficiency Under Fired Broilers
  - Commercial Ozone Laundry Treatment
  - Commercial Energy Star Dishwashers
- Free Ridership values for Demand Control Ventilation – New Construction and Retrofit

This application includes:
- Current approved measures assumptions.

The application contains the following exhibits:
Exhibit A, Tab 1, Schedule 1 Table of Contents
Exhibit B, Tab 1, Schedule 1 Background and Introduction
Exhibit B, Tab 1, Schedule 2 Updated Table of Measure Assumptions
Exhibit B, Tab 1, Schedule 3 New and Updated Substantiation Documents

This application was prepared jointly by Union and Enbridge. Please direct correspondence on this file to both Union and Enbridge representatives:

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Union and Enbridge request the Board’s approval of the new and updated DSM measures.

Sincerely,

[Original signed by]

Vanessa Innis
Manager, Regulatory Initiatives
Union Gas Limited

c.c.: Dennis M. O'Leary
Stephanie Allman – Enbridge Gas Distribution Inc.
EB-2011-0295 Intervenors

Alexander Smith (Torys)
EB-2011-0327 Intervenors

TEC Members:
Ted Kesik – Independent Member
Bob Wirtshafter – Independent Member
Jay Shepherd – School Energy Coalition
Julie Girvan – Consumers Council of Canada
Chris Neme – Green Energy Coalition
Tina Nicholson – Union Gas Limited
Ravi Sigurdson – Enbridge Gas Distribution Inc.

EXHIBIT LIST

Exhibit	Tab	Schedule	Description	Witness
A	1	1	Table of Contents	T. Nicholson/ R. Sigurdson
B	1	1	Background and Introduction	T. Nicholson/ R. Sigurdson
B	1	2	Updated Table of Measure Assumptions	T. Nicholson/ R. Sigurdson
B	1	3	New and Updated Substantiation Documents	T. Nicholson/ R. Sigurdson

BACKGROUND AND INTRODUCTION

1. The Demand Side Management Guidelines for Natural Gas Utilities ("DSM Guidelines"; EB-2008-0346), encourages Enbridge Gas Distribution ("Enbridge") and Union Gas Limited ("Union") to file a joint application of approved input assumption on an annual basis:

   > "The application should be made annually, whether or not the natural gas utilities are requesting any changes to their set of input assumptions. The natural gas utilities' annual application will provide a Board forum for stakeholders that will allow them to, among other things, request updates and/or additions to the set of input assumptions that may not have been identified by the natural gas utilities."[1]

2. A joint Table of Measures Assumptions filed in 2012 brought together a common set of Substantiation Documents providing detailed information and savings calculations for each measure listed.

3. The DSM Guidelines request that a Terms of Reference for Stakeholder Engagement ("Terms of Reference"; EB-2011-0295 Exhibit B, Tab 2, Schedule 9, Appendix A) be developed by the natural gas utilities in cooperation with stakeholders for the multi-year plan period. Under the Terms of Reference, Enbridge and Union have engaged extensively with stakeholders through each utility's DSM Consultative, the utilities' respective Audit Committees and a joint Technical Evaluation Committee ("TEC").

4. The Terms of Reference for Stakeholder Engagement mandates the TEC to develop a Technical Reference Manual for natural gas DSM activities. In

[1] Demand Side Management Guidelines for Natural Gas Utilities, EB-2008-0346, Ontario Energy Board, June 30, 2011, page 19.

2013, the utilities, through the TEC, engaged a third party consultant to begin development of the Technical Reference Manual ("TRM").

5. Once completed, the TRM will replace the Table of Measure Assumptions, documenting efficiency measures savings assumptions and supporting information (e.g. algorithms, formulae, reference materials).

This Update includes the following TEC endorsed elements:

Update Element	Measure(s)	Utility
New Measures	• Residential High Efficiency Water Heaters • Commercial Demand Control Ventilation	Both
Update to Measures	• Residential and Low Income Faucet Aerators (Bathroom & Kitchen) • Residential and Low Income Pipe Wrap • Commercial Energy Star Fryers • Commercial Energy Star Convection Ovens • Commercial Energy Star Steam Cookers • Commercial High Efficiency Under Fired Broilers • Commercial Ozone Laundry Treatment • Commercial Energy Star Dishwashers	Both
Update to Free Ridership Value	• Demand Control Ventilation	Both

6. This application is comprised of the following exhibits:

- Exhibit B, Tab 1, Schedule 2 presents the Updated Table of Measure Assumptions; and
- Exhibit B, Tab 1, Schedule 3 presents updated substantiation documents for the new and updated measures noted in the table above.

	Indicates an update (March 2015) to Board-approved list of input assumptions

Target Market		Equipment Details				Annual Resource Savings			Other				
Sector	New/Existing	Efficient Equipment	Details of Efficient Equipment	Base Equipment	Details of Base Equipment	Natural Gas (m3)	Electricity (kWh)	Water (L)	EUL	Incremental Cost ($)	Free Rider (%)	Utility Measure Applies to	Decision Type
Residential Space Heating													
Residential	Existing	Attic Insulation	upgrade to R-40	R-10		105	105	0	20	$ 580.00	33%	UG	Retrofit
Residential	Existing	Basement Wall Insulation	upgrade to R-12	R-1		261	145	0	25	$ 1,654.00	33%	UG	Retrofit
Residential	Existing	Draft Proofing Kit	(1) Spray Foam, can (1) Caulk, tube (30 ft) Foam Tape (4) Energy Saver Gasket with 2 child safety inserts	No Draft Proofing Kit		236	27	0	1	$ 20.00	55%	UG	Retrofit
Residential	New	Energy Star Home	version 3	Home built to OBC 2006		1,018	1,450	0	25	$ 3,200.00	48%	EGD	New
Residential	Existing	Fireplace intermittent ignition control retrofit		Natural gas fireplace with a pilot		104	-31	0	8	$ 150.00	1%	UG	Retrofit
Residential	Existing	High Efficiency Condensing Furnace	AFUE 96	High-Efficiency Furnace	AFUE 90	129	0	0	18	$ 1,767.00	0%	EGD	Replacement
Residential	New	High Efficiency Fireplace with Pilotless Ignition	Freestanding, Minimum 70% EnerGuide Rating	Freestanding fireplace	65% median efficiency	110	-31	0	20	$ 135.00	17%	EGD	New
Residential	New	High Efficiency Fireplace with Pilotless Ignition	Insert, Minimum 60% EnerGuide Rating	Insert	55% median efficiency	109	-31	0	20	$ 135.00	17%	EGD	New
Residential	New	High Efficiency Fireplace with Pilotless Ignition	Zero Clearance, >= 40 kBtu.h =Minimum 60% EnerGuide Rating	Zero Clearance		122	-31	0	20	$ 135.00	17%	EGD	New
Residential	New	High Efficiency Fireplace with Pilotless Ignition	Zero Clearance, < 40 kBtu.h =Minimum 70% EnerGuide Rating	Zero Clearance		108	-31	0	20	$ 135.00	17%	EGD	New
Residential	Existing	High Efficiency Fireplace with Pilotless Ignition	Freestanding, Minimum 70% EnerGuide Rating	Freestanding fireplace	65% median efficiency	110	-31	0	20	$ 135.00	17%	EGD	Replacement
Residential	Existing	High Efficiency Fireplace with Pilotless Ignition	Insert, Minimum 60% EnerGuide Rating	Insert	55% median efficiency	109	-31	0	20	$ 135.00	17%	EGD	Replacement
Residential	Existing	High Efficiency Fireplace with Pilotless Ignition	Zero Clearance, >= 40 kBtu.h =Minimum 60% EnerGuide Rating	Zero Clearance		122	-31	0	20	$ 135.00	17%	EGD	Replacement
Residential	Existing	High Efficiency Fireplace with Pilotless Ignition	Zero Clearance, < 40 kBtu.h =Minimum 70% EnerGuide Rating	Zero Clearance		108	-31	0	20	$ 135.00	17%	EGD	Replacement
Residential	New	Programmable Thermostat		Standard Thermostat		53	54	0	15	$ 25.00	10%	UG	New
Residential	Existing	Programmable Thermostat		Standard Thermostat		53	54	0	15	$ 25.00	43%	UG	Retrofit
Residential	New	Programmable Thermostat		Standard Thermostat		53	54	0	15	$ 53.22	10%	EGD	New
Residential	Existing	Programmable Thermostat		Standard Thermostat		53	54	0	15	$ 50.00	43%	EGD	Retrofit
Residential	Existing	Reflector Panels		No reflector panels		143	0	0	18	$ 229.00	0%	UG	Retrofit
Residential	Existing	Reflector Panels		Radiant heat w/o reflector panels		143	0	0	18	$ 238.00	0%	EGD	Retrofit
Residential Water Heating													
Residential	New/Existing	Faucet Aerator	Bathroom, 1.5 GPM	Standard flow bathroom aerator (code compliant)	2.2 GPM	3.73	0	1459	10	$ 0.60	31%	EGD	New/Retrofit
Residential	New/Existing	Faucet Aerator	Bathroom, 1.0 GPM	Standard flow bathroom aerator (code compliant)	2.2 GPM	6	0	2,501	10	$ 0.60	33%	UG	New/Retrofit
Residential	New/Existing	Faucet Aerator	Bathroom, 1.0 GPM	Standard flow bathroom aerator (code compliant)	2.2 GPM	6	0	2,501	10	$ 0.60	31%	EGD	New/Retrofit
Residential	New/Existing	Faucet Aerator	Bathroom, 1.5 GPM	Standard flow bathroom aerator (code compliant)	2.2 GPM	3.73	0	1459	10	$ 0.60	33%	UG	New/Retrofit
Residential	New/Existing	Faucet Aerator	Kitchen, 1.0 GPM	Standard flow kitchen aerator (code compliant)	2.2 GPM	20	0	7,742	10	$ 1.14	33%	UG	New/Retrofit
Residential	New/Existing	Faucet Aerator	Kitchen, 1.5 GPM	Standard flow kitchen aerator (code compliant)	2.2 GPM	12	0	4,516	10	$ 1.14	33%	UG	New/Retrofit
Residential	New/Existing	Faucet Aerator	Kitchen, 1.0 GPM	Standard flow kitchen aerator (code compliant)	2.2 GPM	20	0	7,742	10	$ 1.14	31%	EGD	New/Retrofit
Residential	New/Existing	Faucet Aerator	Kitchen, 1.5 GPM	Standard flow kitchen aerator (code compliant)	2.2 GPM	12	0	4,516	10	$ 1.14	31%	EGD	New/Retrofit
Residential	New	Low-flow showerhead	1.25 & 1.5 GPM (Per Household)	Average Existing Stock	2.5 GPM	48	0	14,391	10	$ 16.76	10%	EGD	New

	Indicates an update (March 2015) to Board-approved list of input assumptions

Target Market		Equipment Details				Annual Resource Savings			Other				
Sector	New/Existing	Efficient Equipment	Details of Efficient Equipment	Base Equipment	Details of Base Equipment	Natural Gas (m3)	Electricity (kWh)	Water (L)	EUL	Incremental Cost ($)	Free Rider (%)	Utility Measure Applies to	Decision Type
Residential	Existing	Low-flow showerhead	1.25 GPM	Replace existing 2.0 GPM	2.0 GPM	33	0	11,584	10	$ 3.79	10%	UG	Retrofit
Residential	New	Low-flow showerhead	1.25 GPM (Per household)	Average Existing Stock	2.5 GPM	53	0	17,187	10	$ 4.26	10%	EGD	New
Residential	New	Low-flow showerhead	1.5 GPM (Per Household)	Average Existing Stock	2.5 GPM	43	0	11,596	10	$ 12.50	10%	EGD	New
Residential	Existing	Low-flow showerhead (Contractor Installed)	1.25 GPM	2.0 -2.5 GPM Showerhead	2.25 GPM	46	0	14,294	10	$ 3.79	10%	UG	Retrofit
Residential	Existing	Low-flow showerhead (Contractor Installed)	1.25 GPM	2.6 + GPM Showerhead	3.0 GPM	88	0	22,580	10	$ 3.79	10%	UG	Retrofit
Residential	Existing	Low-flow showerhead (Distributed)	1.25 GPM	2.6 + GPM Showerhead	3.07 GPM	82	0	23,374	10	$ 4.26	10%	EGD	Retrofit
Residential	Existing	Low-flow showerhead (Distributed)	1.25 GPM	2.0 -2.5 GPM Showerhead	2.45 GPM	50	0	16,631	10	$ 4.26	10%	EGD	Retrofit
Residential	New/Existing	Low-flow showerhead (Distributed)	1.25 GPM	Average existing stock	2.2 GPM	44	0	13,885	10	$ 3.79	10%	UG	New/Retrofit
Residential	Existing	Low-flow showerhead (Installed)	1.25 GPM	2.0 -2.5 GPM Showerhead	2.45 GPM	50	0	16,631	10	$ 19.00	10%	EGD	Retrofit
Residential	Existing	Low-flow showerhead (Installed)	1.25 GPM	2.6 + GPM Showerhead	3.07 GPM	82	0	23,374	10	$ 19.00	10%	EGD	Retrofit
Residential	Existing	Pipe Wrap	R-3.75	No pipe wrap	R-0.43	4.72 m3/ft	0	0	15	$0.25/ft	4%	Both	Retrofit
Residential	Existing	Solar Pool Heaters		Natural gas pool heater		1,116	-57	0	20	$ 1,450.00	10%	Both	Retrofit
Residential	New/Existing	Tankless Water Heater	EF 0.82	Storage Tank Water Heater		142	0	0	18	$ 750.00	2%	UG	New/Replacement
Residential	Existing	Tankless Water Heater		Storage Tank Water Heater		130	0	0	18	$ 750.00	2%	EGD	Replacement
Residential	New	High Efficiency Gas Storage Water Heaters	High efficiency storage tank water heater (Energy Factor of 0.80)	ENERGY STAR power vented storage tank water heater	Energy factor of 0.67	68.3	0	0	16	$ 540.00		Both	New

Low-Income Space Heating

Low-Income	Existing	Early Furnace Replacement - 60% AFUE	90% AFUE Furnace	60% AFUE Furnace		781	0	0	3	$ 518.00	0%	UG	Retrofit
Low-Income	Existing	Early Furnace Replacement - 70% AFUE	90% AFUE Furnace	70% AFUE Furnace		466	0	0	3	$ 518.00	0%	UG	Retrofit
Low-Income	Existing	Programmable Thermostat		Standard manual thermostat		53	54	0	15	$ 26.95	1%	UG	Retrofit
Low Income	Existing	Programmable Thermostat		Standard Thermostat		53	54	0	15	$ 69.18	0%	EGD	Retrofit

Low-Income Water Heating

Low-Income	Existing	Early Hot Water Heater Replacement (0.575 to 0.62 EF)	0.62 EF Water Heater	0.575 EF Water Heater		80	0	0	3	$ 168.00	1%	UG	Retrofit
Low-Income	New/Existing	Faucet Aerator	Bathroom, 1.0 GPM	Standard flow bathroom aerator (code compliant)	2.2 GPM	6	0	2,501	10	$ 0.60	1%	UG	New/Retrofit
Low-Income	New/Existing	Faucet Aerator	Bathroom, 1.5 GPM	Standard flow bathroom aerator (code compliant)	2.2 GPM	3.73	0	1459	10	$ 0.60	1%	UG	New/Retrofit
Low-Income	New/Existing	Faucet Aerator	Kitchen, 1.0 GPM	Standard flow kitchen aerator (code compliant)	2.2 GPM	20	0	7,742	10	$ 1.14	1%	UG	New/Retrofit
Low-Income	New/Existing	Faucet Aerator	Kitchen, 1.5 GPM	Standard flow kitchen aerator (code compliant)	2.2 GPM	12	0	4,516	10	$ 1.14	1%	UG	New/Retrofit
Low Income	New/Existing	Faucet Aerator	Bathroom, 1.0 GPM	Standard flow bathroom aerator (code compliant)	2.2 GPM	6	0	2,501	10	$ 0.60	0%	EGD	New/Retrofit
Low Income	New/Existing	Faucet Aerator	Kitchen, 1.5 GPM	Standard flow bathroom aerator (code compliant)	2.2 GPM	3.73	0	1459	10	$ 0.60	0%	EGD	New/Retrofit
Low Income	New/Existing	Faucet Aerator	Kitchen, 1.0 GPM	Standard flow kitchen aerator (code compliant)	2.2 GPM	20	0	7,742	10	$ 1.14	0%	EGD	New/Retrofit

(shaded)	Indicates an update (March 2015) to Board-approved list of input assumptions

Target Market		Equipment Details				Annual Resource Savings			Other				
Sector	New/Existing	Efficient Equipment	Details of Efficient Equipment	Base Equipment	Details of Base Equipment	Natural Gas (m3)	Electricity (kWh)	Water (L)	EUL	Incremental Cost ($)	Free Rider (%)	Utility Measure Applies to	Decision Type
Low Income	New/Existing	Faucet Aerator	Bathroom, 1.5 GPM	Standard flow bathroom aerator (code compliant)	2.2 GPM	3.73	0	1459	10	$ 0.60	0%	EGD	New/Retrofit
Low Income	Existing	Low-flow showerhead	1.25 GPM (Installed)	2.0 -2.5 GPM Showerhead	2.45 GPM	50	0	16,631	10	$ 18.71	0%	EGD	Retrofit
Low Income	Existing	Low-flow showerhead	1.25 GPM (Installed)	2.6 + GPM Showerhead	3.07 GPM	82	0	23,374	10	$ 18.71	0%	EGD	Retrofit
Low income	Existing	Low-flow showerhead	2.0 GPM	2.0 -2.5 GPM Showerhead	2.45	20	0	3418	10	$ 18.71	0%	EGD	Retrofit
Low income	Existing	Low-flow showerhead	2.0 GPM	2.6 + GPM Showerhead	3.07	52	0	7938	10	$ 18.71	0%	EGD	Retrofit
Low-Income	Existing	Low-flow showerhead (Contractor installed)	1.25 GPM	Average existing stock	2.25 GPM	46	0	14,294	10	$ 3.79	1%	UG	Retrofit
Low-Income	Existing	Low-flow showerhead (Contractor installed)	1.25 GPM	Average existing stock	3.0 GPM	88	0	22,580	10	$ 3.79	1%	UG	Retrofit
Low-Income	Existing	Pipe Wrap	R 3 - 3.75	No pipe wrap	R-0.43	3.97 m3/ft	0	0	15	$0.25/ft	UG 1%, EGD 0%	Both	Retrofit
Low-Income	Existing	Low-flow showerhead	1.25 GPM	Replace existing 2.0 GPM	2.0 GPM	33	0	11,584	10	$ 3.79	1%	UG	Retrofit

Low-Income Multi-Family Water Heating

Sector	New/Existing	Efficient Equipment	Details of Efficient Equipment	Base Equipment	Details of Base Equipment	Natural Gas (m3)	Electricity (kWh)	Water (L)	EUL	Incremental Cost ($)	Free Rider (%)	Utility Measure Applies to	Decision Type
Low-Income	New/Existing	Faucet Aerator	Bathroom, 1.0 GPM	Standard flow bathroom aerator (code compliant)	2.2 GPM	6	0	2,501	10	$ 0.60	1%	UG	New/Retrofit
Low-Income	New/Existing	Faucet Aerator	Bathroom, 1.5 GPM	Standard flow bathroom aerator (code compliant)	2.2 GPM	3.73	0	1459	10	$ 0.60	1%	UG	New/Retrofit
Low-Income	New/Existing	Faucet Aerator	Kitchen, 1.0 GPM	Standard flow kitchen aerator (code compliant)	2.2 GPM	20	0	7,742	10	$ 1.14	1%	UG	New/Retrofit
Low-Income	New/Existing	Faucet Aerator	Kitchen, 1.5 GPM	Standard flow kitchen aerator (code compliant)	2.2 GPM	12	0	4,516	10	$ 1.14	1%	UG	New/Retrofit
Low Income	New/Existing	Faucet Aerator	Bathroom, 1.0 GPM	Standard flow bathroom aerator (code compliant)	2.2 GPM	6	0	2,501	10	$ 0.60	0%	EGD	New/Retrofit
Low Income	New/Existing	Faucet Aerator	Bathroom, 1.5 GPM	Standard flow bathroom aerator (code compliant)	2.2 GPM	3.73	0	1459	10	$ 0.60	0%	EGD	New/Retrofit
Low Income	New/Existing	Faucet Aerator	Kitchen, 1.0 GPM	Standard flow kitchen aerator (code compliant)	2.2 GPM	20	0	7,742	10	$ 1.14	0%	EGD	New/Retrofit
Low Income	New/Existing	Faucet Aerator	Kitchen, 1.5 GPM	Standard flow bathroom aerator (code compliant)	2.2 GPM	3.73	0	1459	10	$ 0.60	0%	EGD	New/Retrofit
Low-Income	Existing	Low-flow showerhead (Distributed)	1.25 GPM	Average existing stock	2.21 GPM	32	0	9,585	10	$ 3.79	1%	UG	Retrofit
Low-Income	Existing	Low-flow showerhead	1.25 GPM	2.0-2.5 GPM showerhead	2.25 GPM	33	0	9,892	10	$ 3.79	1%	UG	Retrofit
Low-Income	Existing	Low-flow showerhead	1.25 GPM	> 2.6 GPM showerhead	3.0 GPM	64	0	15,549	10	$ 3.79	1%	UG	Retrofit
Low-Income	Existing	Low-flow showerhead	1.25 GPM	Replace existing 1.5 GPM	1.5 GPM	8	0	3,846	10	$ 3.79	1%	UG	Retrofit
Low-Income	Existing	Low-flow showerhead	1.25 GPM	Replace existing 2.0 GPM	2.0 GPM	24	0	7,933	10	$ 3.79	1%	UG	Retrofit
Low Income	Existing	Low-Flow Showerhead (Per household, Installed)	1.5 GPM	2.0 -2.5 GPM showerhead	2.25 GPM	21	0	5,931	10	$ 12.50	0%	EGD	Retrofit
Low Income	Existing	Low-Flow Showerhead (Per household, Installed)	1.5 GPM	2.6 -3.0 GPM GPM showerhead	2.8 GPM	40	0	10,036	10	$ 12.50	0%	EGD	Retrofit
Low Income	Existing	Low-Flow Showerhead (Per household, Installed)	1.5 GPM	3.1 - 3.5 GPM showerhead	3.3 GPM	58	0	13,621	10	$ 12.50	0%	EGD	Retrofit
Low Income	Existing	Low-Flow Showerhead (Per household, Installed)	1.5 GPM	3.6 GPM and above	3.6 GPM	69	0	15,705	10	$ 12.50	0%	EGD	Retrofit
Low Income	Existing	Low-Flow Showerhead (Per household, Installed)	2.0 GPM	2.0 -2.5 GPM showerhead	2.25 GPM	7.6	0	1913	10	$ 18.71	0%	EGD	Retrofit
Low Income	Existing	Low-Flow Showerhead (Per household, Installed)	2.0 GPM	2.6 -3.0 GPM GPM showerhead	2.8 GPM	26	0	5996	10	$ 18.71	0%	EGD	Retrofit
Low Income	Existing	Low-Flow Showerhead (Per household, Installed)	2.0 GPM	3.1 - 3.5 GPM showerhead	3.3 GPM	44	0	9559	10	$ 18.71	0%	EGD	Retrofit
Low Income	Existing	Low-Flow Showerhead (Per household, Installed)	2.0 GPM	3.6 GPM and above	3.6 GPM	55	0	11628	10	$ 18.71	0%	EGD	Retrofit

Low-Income Multi-Family Space Heating

Sector	New/Existing	Efficient Equipment	Details of Efficient Equipment	Base Equipment	Details of Base Equipment	Natural Gas (m3)	Electricity (kWh)	Water (L)	EUL	Incremental Cost ($)	Free Rider (%)	Utility Measure Applies to	Decision Type
Low income	New	Condensing Boiler - Space Heating (<100 Mbtu/h)	90% AFUE	Non-condensing Boiler	82% AFUE	0.01019 /Btu/hr	0	0	25	$ 1,475.00	Union 5%, EGD 0%	Both	New
Low income	New	Condensing Boiler - Space Heating (100 to 199 Mbtu/h)	90% AFUE	Non-condensing Boiler	82% AFUE	0.01019 /Btu/hr	0	0	25	$ 2,414.00	Union 5%, EGD 0%	Both	New
Low income	New	Condensing Boiler - Space Heating (200 to 299 Mbtu/h)	90% AFUE	Non-condensing Boiler	82% AFUE	0.01019 /Btu/hr	0	0	25	$ 3,227.00	Union 5%, EGD 0%	Both	New
Low income	Existing	Condensing Boiler - Space Heating (<100 Mbtu/h)	90% AFUE	Non-condensing Boiler	82% AFUE	0.01019 /Btu/hr	0	0	25	$ 2,045.00	Union 5%, EGD 0%	Both	Replacement
Low income	Existing	Condensing Boiler - Space Heating (100 to 199 Mbtu/h)	90% AFUE	Non-condensing Boiler	82% AFUE	0.01019 /Btu/hr	0	0	25	$ 2,984.00	Union 5%, EGD 0%	Both	Replacement

	Indicates an update (March 2015) to Board-approved list of input assumptions

Target Market		Equipment Details				Annual Resource Savings			Other				
Sector	New/Existing	Efficient Equipment	Details of Efficient Equipment	Base Equipment	Details of Base Equipment	Natural Gas (m3)	Electricity (kWh)	Water (L)	EUL	Incremental Cost ($)	Free Rider (%)	Utility Measure Applies to	Decision Type
Low income	Existing	Condensing Boiler - Space Heating (200 to 299 Mbtu/h)	90% AFUE	Non-condensing Boiler	82% AFUE	0.01019 /Btu/hr	0	0	25	$ 3,797.00	Union 5%, EGD 0%	Both	Replacement
Low income	New/Existing	Condensing Boilers - Space Heating, 300 and above MBTUH	88% seasonal efficiency	Non-condensing boiler	76% estimated seasonal efficiency	0.0104 m3/Btu/hr	0	0	25	$12/Kbtu/hr	5%	UG	New/Replacement
Low income	New	High Efficiency Boiler - Space Heating (<100 Mbtu/h)	85% AFUE	Non-condensing Boiler	82% AFUE	0.00318 /Btu/hr	0	0	25	$ 1,238.00	Union 5%, EGD 0%	Both	New
Low income	New	High Efficiency Boiler - Space Heating (100 to 199 Mbtu/h)	85% AFUE	Non-condensing Boiler	82% AFUE	0.00318 /Btu/hr	0	0	25	$ 1,544.00	Union 5%, EGD 0%	Both	New
Low income	New	High Efficiency Boiler - Space Heating (200 to 299 Mbtu/h)	85% AFUE	Non-condensing Boiler	82% AFUE	0.00318 /Btu/hr	0	0	25	$ 1,388.00	Union 5%, EGD 0%	Both	New
Low income	Existing	High Efficiency Boiler - Space Heating (<100 Mbtu/h)	85% AFUE	Non-condensing Boiler	82% AFUE	0.00318 /Btu/hr	0	0	25	$ 1,808.00	Union 5%, EGD 0%	Both	Replacement
Low income	Existing	High Efficiency Boiler - Space Heating (100 to 199 Mbtu/h)	85% AFUE	Non-condensing Boiler	82% AFUE	0.00318 /Btu/hr	0	0	25	$ 2,114.00	Union 5%, EGD 0%	Both	Replacement
Low income	Existing	High Efficiency Boiler - Space Heating (200 to 299 Mbtu/h)	85% AFUE	Non-condensing Boiler	82% AFUE	0.00318 /Btu/hr	0	0	25	$ 1,958.00	Union 5%, EGD 0%	Both	Replacement
Low income	Existing	Prescriptive High Efficiency Boiler - Space Heating	83-84% Efficient, 300-2000 MBH	Space Heating Boiler	80.5% Thermal Efficiency	2,474-19,340	0	0	25	$3900-$4950	Union 5%, EGD 0%	Both	Replacement
Low income	Existing	Prescriptive High Efficiency Boiler - Space Heating	85-88% Efficient, 300-2000 MBH	Space Heating Boiler	80.5% Thermal Efficiency	3,496-27,325	0	0	25	$4,500-$7,050	Union 5%, EGD 0%	Both	Replacement
Low income	New	Prescriptive High Efficiency Boiler - Space Heating	83-84% Efficient, 300-2000 MBH	Space Heating Boiler	80.5% Thermal Efficiency	2,474-19,340	0	0	25	$3900-$4950	Union 5%, EGD 0%	Both	New
Low income	New	Prescriptive High Efficiency Boiler - Space Heating	85-88% Efficient, 300-2000 MBH	Space Heating Boiler	80.5% Thermal Efficiency	3,496-27,325	0	0	25	$4,500-$7,050	Union 5%, EGD 0%	Both	New

Commercial Cooking

Commercial	New/Existing	Energy Star Fryer	Energy Star Rated Fryer	Non-Energy Star rated Fryer		1408	0	0	12	$ 3,405.00	20%	Both	New/Replacement
Commercial	New/Existing	Energy Star Convection Ovens - Full Size	Energy Star Rated Convection Oven (Full Size)	Conventional Convection Oven (Full Size)		865	0	0	12	$ 875.00	20%	Both	New/Replacement
Commercial	New/Existing	Energy Star Steam Cookers	Energy Star Rated Steam Cooker	Boiler-based steam cooker		8889	0	340142	12	$ 1,035.00	20%	Both	New/Replacement
Commercial	New/Existing	High Efficiency Under-Fired Broilers - 3 foot	pre-heat =< 40,500 Btu and cooking energy rate =< 72,000 Btu/hr	Conventional Efficiency Under-Fired Broiler	pre-heat =< 48,000 Btu and cooking energy rate =< 96,000 Btu/hr	2,511	0	0	12	$ 1,900.00	20%	Both	New/Replacement
Commercial	New/Existing	High Efficiency Under-Fired Broilers - 4 foot	pre-heat 40,501 to 54,000 Btu and a cooking energy rate 72,001 to 96,000 Btu/hr	Conventional Efficiency Under-Fired Broiler	pre-heat 48,001 to 64,000 Btu and a cooking energy rate 96,000 to 128,000 Btu/hr	3,347	0	0	12	$ 1,900.00	20%	Both	New/Replacement
Commercial	New/Existing	High Efficiency Under-Fired Broilers - 5 foot	pre-heat 54,001 to 67,500 Btu and cooking energy rate 96,001 to 120,000 Btu/hr	Conventional Efficiency Under-Fired Broiler	pre-heat 64,001 to 80,000 Btu and cooking energy rate 128,001 to 160,000 Btu/hr	4,184	0	0	12	$ 1,900.00	20%	Both	New/Replacement
Commercial	New/Existing	High Efficiency Under-Fired Broilers - 6 foot	pre-heat 67,501 to 81,000 Btu and cooking energy rate 120,001 to 144,000 Btu/hr	Conventional Efficiency Under-Fired Broiler	pre-heat 80,001 to 96,000 Btu and cooking energy rate 160,001 to 192,000 Btu/hr	5,021	0	0	12	$ 1,900.00	20%	Both	New/Replacement

Commercial Space Heating

Commercial	Existing	Air Curtains	Double door	Non-air curtain doors		1,529	1,023	0	15	$ 2,500.00	5%	Both	Retrofit
Commercial	New/Existing	Air Curtains	Shipping and Receiving Doors (10 x 10)	Non-air curtain doors		20,605	-936	0	15	$ 10,170.00	5%	Both	New/Retrofit
Commercial	New/Existing	Air Curtains	Shipping and Receiving Doors (8 x 10)	Non-air curtain doors		9,457	-5,220	0	15	$ 8,242.00	5%	Both	New/Retrofit
Commercial	New/Existing	Air Curtains	Shipping and Receiving Doors (8 x 8)	Non-air curtain doors		7,565	-5,380	0	15	$ 8,242.00	5%	Both	New/Retrofit
Commercial	Existing	Air Curtains	Single door	Non-air curtain doors		667	172	0	15	$ 1,650.00	5%	Both	Retrofit
Commercial	New	Condensing Boiler - Space Heating (<100 Mbtu/h)	90% AFUE	Non-condensing Boiler	82% AFUE	0.01019 /Btu/hr	0	0	25	$ 1,475.00	5%	Both	New
Commercial	New	Condensing Boiler - Space Heating (100 to 199 Mbtu/h)	90% AFUE	Non-condensing Boiler	82% AFUE	0.01019 /Btu/hr	0	0	25	$ 2,414.00	5%	Both	New
Commercial	New	Condensing Boiler - Space Heating (200 to 299 Mbtu/h)	90% AFUE	Non-condensing Boiler	82% AFUE	0.01019 /Btu/hr	0	0	25	$ 3,227.00	5%	Both	New
Commercial	Existing	Condensing Boiler - Space Heating (<100 Mbtu/h)	90% AFUE	Non-condensing Boiler	82% AFUE	0.01019 /Btu/hr	0	0	25	$ 2,045.00	5%	Both	Replacement

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Target Market		Equipment Details				Annual Resource Savings			Other				
Sector	New/Existing	Efficient Equipment	Details of Efficient Equipment	Base Equipment	Details of Base Equipment	Natural Gas (m3)	Electricity (kWh)	Water (L)	EUL	Incremental Cost ($)	Free Rider (%)	Utility Measure Applies to	Decision Type
Commercial	Existing	Condensing Boiler - Space Heating (100 to 199 Mbtu/h)	90% AFUE	Non-condensing Boiler	82% AFUE	0.01019 /Btu/hr	0	0	25	$ 2,984.00	5%	Both	Replacement
Commercial	Existing	Condensing Boiler - Space Heating (200 to 299 Mbtu/h)	90% AFUE	Non-condensing Boiler	82% AFUE	0.01019 /Btu/hr	0	0	25	$ 3,797.00	5%	Both	Replacement
Commercial	New/Existing	Condensing Boilers - Space Heating, 300 and above MBTUH	88% seasonal efficiency	Non-condensing boiler	76% estimated seasonal efficiency	0.0104 m3/Btu/hr	0	0	25	$12/Kbtu/hr	5%	UG	New/Replacement
Commercial	New/Existing	Condensing Make Up Air Unit - MR and LTC		Conventional MUA with constant speed drive		.84 m3/cfm - 2.92 m3/cfm	(0.00-1.48) kwh/cfm		15	$870 + (.66 - 1.02) per cfm	5%	Both	New/Replacement
Commercial	New/Existing	Condensing Make Up Air Unit - Retail and Comm		Conventional MUA with constant speed drive		.41 m3/cfm - 2.07 m3/cfm	(0.00-1.09) kwh/cfm		15	$870 + (.66 - 1.02) per cfm	5%	Both	New/Replacement
Commercial	New/Existing	Condensing Unit Heater		% Sales Weighted Average model	78% Annually Efficient	0.00631 m3/Btu/hr	(-)0.00186 kwh/Btu/hr	0	18	$0.0129 /Btu/hr	0%	Both	New/Replacement
Commercial	New/Existing	Demand Control Kitchen Ventilation	0 - 4,999 CFM	Kitchen ventilation without DCKV		4,801	13,521	0	15	$ 10,000.00	5%	Both	New/Replacement
Commercial	New/Existing	Demand Control Kitchen Ventilation	10,000 - 15,000 CFM	Kitchen ventilation without DCKV		18,924	49,102	0	15	$ 20,000.00	5%	Both	New/Replacement
Commercial	New/Existing	Demand Control Kitchen Ventilation	5,000 - 9,999 CFM	Kitchen ventilation without DCKV		11,486	30,901	0	15	$ 15,000.00	5%	Both	New/Replacement
Commercial	New/Existing	Destratification Fans		No destratification fans		0.5 m3/ft^2	(-)0.0034 kwh/ft^2	0	15	$ 7,021.00	10%	Both	New/Retrofit
Commercial	New	Energy Recovery Ventilation (Multi-Family, Health Care, Nursing Home)	Ventilation with ERV	Ventilation without ERV		5.77 m3/CFM	0	0	14	$3.18/CFM	5%	Both	New
Commercial	Existing	Energy Recovery Ventilation (Multi-Family, Health Care, Nursing Home)	Ventilation with ERV	Ventilation without ERV		6.12 m3/CFM	0	0	14	$3.18/CFM	5%	Both	Retrofit
Commercial	New	Energy Recovery Ventilation (Hotel, Restaurant, Retail)	Ventilation with ERV	Ventilation without ERV		3.21 m3/CFM	0	0	14	$3.18/CFM	5%	Both	New
Commercial	Existing	Energy Recovery Ventilation (Hotel, Restaurant, Retail)	Ventilation with ERV	Ventilation without ERV		3.4 m3/CFM	0	0	14	$3.18/CFM	5%	Both	Retrofit
Commercial	New	Energy Recovery Ventilation (Office, Warehouse, School)	Ventilation with ERV	Ventilation without ERV		2.05 m3/CFM	0	0	14	$3.18/CFM	5%	Both	New
Commercial	Existing	Energy Recovery Ventilation (Office, Warehouse, School)	Ventilation with ERV	Ventilation without ERV		2.17 m3/CFM	0	0	14	$3.18/CFM	5%	Both	Retrofit
Commercial	New	Heat Recovery Ventilation (Multi-Family, Health Care, Nursing Home)	Ventilation with HRV	Ventilation without HRV		4.28 m3/CFM	0	0	14	$3.61/CFM	5%	Both	New
Commercial	Existing	Heat Recovery Ventilation (Multi-Family, Health Care, Nursing Home)	Ventilation with HRV	Ventilation without HRV		4.70 m3/CFM	0	0	14	$3.61/CFM	5%	Both	Retrofit
Commercial	New	Heat Recovery Ventilation (Hotel, Restaurant, Retail)	Ventilation with HRV	Ventilation without HRV		2.38 m3/CFM	0	0	14	$3.61/CFM	5%	Both	New
Commercial	Existing	Heat Recovery Ventilation (Hotel, Restaurant, Retail)	Ventilation with HRV	Ventilation without HRV		2.61 m3/CFM	0	0	14	$3.61/CFM	5%	Both	Retrofit
Commercial	New	Heat Recovery Ventilation (Office, Warehouse, School)	Ventilation with HRV	Ventilation without HRV		1.52 m3/CFM	0	0	14	$3.61/CFM	5%	Both	New
Commercial	Existing	Heat Recovery Ventilation (Office, Warehouse, School)	Ventilation with HRV	Ventilation without HRV		1.67 m3/CFM	0	0	14	$3.61/CFM	5%	Both	Retrofit
Commercial	New	High Efficiency Boiler - Space Heating (<100 Mbtu/h)	85% AFUE	Non-condensing Boiler	82% AFUE	0.00318 /Btu/hr	0	0	25	$ 1,238.00	5%	Both	New
Commercial	New	High Efficiency Boiler - Space Heating (100 to 199 Mbtu/h)	85% AFUE	Non-condensing Boiler	82% AFUE	0.00318 /Btu/hr	0	0	25	$ 1,544.00	5%	Both	New
Commercial	New	High Efficiency Boiler - Space Heating (200 to 299 Mbtu/h)	85% AFUE	Non-condensing Boiler	82% AFUE	0.00318 /Btu/hr	0	0	25	$ 1,388.00	5%	Both	New
Commercial	Existing	High Efficiency Boiler - Space Heating (<100 Mbtu/h)	85% AFUE	Non-condensing Boiler	82% AFUE	0.00318 /Btu/hr	0	0	25	$ 1,808.00	5%	Both	Replacement
Commercial	Existing	High Efficiency Boiler - Space Heating (100 to 199 Mbtu/h)	85% AFUE	Non-condensing Boiler	82% AFUE	0.00318 /Btu/hr	0	0	25	$ 2,114.00	5%	Both	Replacement
Commercial	Existing	High Efficiency Boiler - Space Heating (200 to 299 Mbtu/h)	85% AFUE	Non-condensing Boiler	82% AFUE	0.00318 /Btu/hr	0	0	25	$ 1,958.00	5%	Both	Replacement
Commercial	Existing	High Efficiency Condensing Furnace	96% AFUE	AFUE 90%		1.7/kBtu/hr	0	0	18	$8.4/kBtu/hr	17.5%	Both	Replacement
Commercial	New/Existing	Single Stage & High Intensity Infrared Heaters	0 - 49,999 BTU/hr	Regular Unit Heater		0.0144 /Btu/hr	16	0	20	$0.0122 /BTUh	33%	Both	New/Replacement
Commercial	New/Existing	2-Stage Infrared Heaters	0 - 49,999 BTU/hr	Regular Unit Heater		0.0242 /Btu/hr	16	0	20	$0.0122 /BTUh	33%	Both	New/Replacement
Commercial	New/Existing	Single Stage & High Intensity Infrared Heaters	165,000 - 300,000 BTU/hr	Regular Unit Heater		0.0144 /Btu/hr	873	0	20	$0.0122 /BTUh	33%	Both	New/Replacement
Commercial	New/Existing	2-Stage Infrared Heaters	165,000 - 300,000 BTU/hr	Regular Unit Heater		0.0242 /Btu/hr	873	0	20	$0.0122 /BTUh	33%	Both	New/Replacement
Commercial	New/Existing	Single Stage & High Intensity Infrared Heaters	50,000 - 164,999 BTU/hr	Regular Unit Heater		0.0144 /Btu/hr	409	0	20	$0.0122 /BTUh	33%	Both	New/Replacement
Commercial	New/Existing	2-Stage Infrared Heaters	50,000 - 164,999 BTU/hr	Regular Unit Heater		0.0242 /Btu/hr	409	0	20	$0.0122 /BTUh	33%	Both	New/Replacement
Commercial	Existing	Prescriptive Higher Efficiency Boiler - Space Heating	83-84% Efficient, 300-2000 MBH	Space Heating Boiler	80.5% Thermal Efficiency	2,474-19,340	0	0	25	$3900-$4950	10/12/20%	Both	Replacement
Commercial	Existing	Prescriptive Higher Efficiency Boiler - Space Heating	85-88% Efficient, 300-2000 MBH	Space Heating Boiler	80.5% Thermal Efficiency	3,496-27,325	0	0	25	$4,500-$7,050	10/12/20%	Both	Replacement
Commercial	New	Prescriptive Higher Efficiency Boiler - Space Heating	83-84% Efficient, 300-2000 MBH	Space Heating Boiler	80.5% Thermal Efficiency	2,474-19,340	0	0	25	$3900-$4950	10/12/20%	Both	New

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Target Market		Equipment Details				Annual Resource Savings			Other				
Sector	New/Existing	Efficient Equipment	Details of Efficient Equipment	Base Equipment	Details of Base Equipment	Natural Gas (m3)	Electricity (kWh)	Water (L)	EUL	Incremental Cost ($)	Free Rider (%)	Utility Measure Applies to	Decision Type
Commercial	New	Prescriptive Higher Efficiency Boiler - Space Heating	85-88% Efficient, 300-2000 MBH	Space Heating Boiler	80.5% Thermal Efficiency	3,496-27,325	0	0	25	$4,500-$7,050	10/12/20%	Both	New
Commercial	Existing	Prescriptive Schools - Elementary	hydronic boiler with 83%+ thermal efficiency	hydronic boiler with 80.5% thermal efficiency		12,217	0	0	25	$ 8,646.00	27%	UG	Replacement
Commercial	Existing	Prescriptive Schools - Elementary	hydronic boiler with 83%+ thermal efficiency	hydronic boiler with 80.5% thermal efficiency		12,217	0	0	25	$ 8,646.00	12%	EGD	Replacement
Commercial	Existing	Prescriptive Schools - Secondary	hydronic boiler with 83%+ thermal efficiency	hydronic boiler with 80.5% thermal efficiency		49,476	0	0	25	$ 14,470.00	27%	UG	Replacement
Commercial	Existing	Prescriptive Schools - Secondary	hydronic boiler with 83%+ thermal efficiency	hydronic boiler with 80.5% thermal efficiency		49,476	0	0	25	$ 14,470.00	12%	EGD	Replacement
Commercial	Existing	Programmable Thermostat		Standard thermostat		13 - 108**	15 - 77**	0	15	$ 110.00	20%	UG	Retrofit
Commercial	Existing	Programmable Thermostat	Educational - School	Standard thermostat		65	8	0	15	$ 110.00	20%	EGD	Retrofit
Commercial	Existing	Programmable Thermostat	Educational - University/College	Standard thermostat		58	57	0	0	$ 110.00	20%	EGD	Retrofit
Commercial	Existing	Programmable Thermostat	Food Service - Restaurant/Tavern	Standard thermostat		69	77	0	15	$ 110.00	20%	EGD	Retrofit
Commercial	Existing	Programmable Thermostat	Hotel/Motel	Standard thermostat		10	11	0	0	$ 110.00	20%	EGD	Retrofit
Commercial	Existing	Programmable Thermostat	Large Hotel	Standard thermostat		10	14	0	0	$ 110.00	20%	EGD	Retrofit
MultiFamily	Existing	Programmable Thermostat	Multi Family	Standard thermostat		15	13	0	15	$ 80.00	20%	Both	Retrofit
Commercial	Existing	Programmable Thermostat	Recreation - Small Fitness / Spa	Standard thermostat		35	87	0	15	$ 110.00	20%	EGD	Retrofit
Commercial	Existing	Programmable Thermostat	Retail - Food	Standard thermostat		22	16	0	15	$ 110.00	20%	EGD	Retrofit
Commercial	Existing	Programmable Thermostat	Retail - Mall	Standard thermostat		14	19	0	15	$ 110.00	20%	EGD	Retrofit
Commercial	Existing	Programmable Thermostat	Retail - Strip Mall	Standard thermostat		11	19	0	15	$ 110.00	20%	EGD	Retrofit
Commercial	Existing	Programmable Thermostat	Small Office	Standard thermostat		39	43	0	0	$ 110.00	20%	EGD	Retrofit
Commercial	Existing	Programmable Thermostat	Warehouse / Wholesale	Standard thermostat		132	9	0	15	$ 110.00	20%	EGD	Retrofit
Commercial	New/Existing	Rooftop Unit	Two-stage rooftop unit	Single stage rooftop unit		255	0	0	15	$ 375.00	5%	Both	New/Replacement
Commercial	New	Demand Control Ventilation	Office	New single-zone, constant volume ventilation system	Provides min outdoor air requirements as specificed in Table 6.2.2.1 of ASHRAE Standard 62.1-2013 [1]	0.112 m3/ft2	0	0	10	$ 1,050.00	20%	Both	New/Replacement
Commercial	New	Demand Control Ventilation (with a documented maintenance plan)	Office	New single-zone, constant volume ventilation system	Provides min outdoor air requirements as specificed in Table 6.2.2.1 of ASHRAE Standard 62.1-2013 [1]	0.112 m3/ft2	0	0	15	$ 1,350.00	20%	Both	New/Replacement
Commercial	New	Demand Control Ventilation	Retail	New single-zone, constant volume ventilation system	Provides min outdoor air requirements as specificed in Table 6.2.2.1 of ASHRAE Standard 62.1-2013 [1]	0.392 m3/ft2	0	0	10	$ 1,050.00	20%	Both	New/Replacement
Commercial	New	Demand Control Ventilation (with a documented maintenance plan)	Retail	New single-zone, constant volume ventilation system	Provides min outdoor air requirements as specificed in Table 6.2.2.1 of ASHRAE Standard 62.1-2013 [1]	0.392 m3/ft2	0	0	15	$ 1,350.00	20%	Both	New/Replacement
Commercial	Existing	Demand Control Ventilation	Office	New single-zone, constant volume ventilation system	Provides min outdoor air requirements as specificed in Table 6.2.2.1 of ASHRAE Standard 62.1-2013 [1]	0.112 m3/ft2	0	0	10	$ 1,350.00	5%	Both	Retrofit
Commercial	Existing	Demand Control Ventilation (with a documented maintenance plan)	Office	New single-zone, constant volume ventilation system	Provides min outdoor air requirements as specificed in Table 6.2.2.1 of ASHRAE Standard 62.1-2013 [1]	0.112 m3/ft2	0	0	15	$ 1,650.00	5%	Both	Retrofit

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Target Market		Equipment Details				Annual Resource Savings			Other				
Sector	New/Existing	Efficient Equipment	Details of Efficient Equipment	Base Equipment	Details of Base Equipment	Natural Gas (m3)	Electricity (kWh)	Water (L)	EUL	Incremental Cost ($)	Free Rider (%)	Utility Measure Applies to	Decision Type
Commercial	Existing	Demand Control Ventilation	Retail	New single-zone, constant volume ventilation system	Provides min outdoor air requirements as specificed in Table 6.2.2.1 of ASHRAE Standard 62.1-2013 [1]	0.392 m3/ft2	0	0	10	$ 1,350.00	5%	Both	Retrofit
Commercial	Existing	Demand Control Ventilation (with a documented maintenance plan)	Retail	New single-zone, constant volume ventilation system	Provides min outdoor air requirements as specificed in Table 6.2.2.1 of ASHRAE Standard 62.1-2013 [1]	0.392 m3/ft2	0	0	15	$ 1,650.00	5%	Both	Retrofit

Commercial Water Heating

Sector	New/Existing	Efficient Equipment	Details of Efficient Equipment	Base Equipment	Details of Base Equipment	Natural Gas (m3)	Electricity (kWh)	Water (L)	EUL	Incremental Cost ($)	Free Rider (%)	Utility Measure Applies to	Decision Type
Commercial	New/Existing	Commercial Ozone Laundry Treatment	Ozone Treatment Washer extractor =< 60 lbs	Commercial laundry with no ozone treatment system		0.0367 m3/lbs/yr	0.00213 kwh/lbs/yr	2.08L/lbs/yr	15	$ 11,000.00	8%	Both	New/Retrofit
Commercial	New/Existing	Commercial Ozone Laundry Treatment	Ozone Treatment Washer extractor 61 lbs to 499 lbs	Commercial laundry with no ozone treatment system		0.0367 m3/lbs/yr	0.00213 kwh/lbs/yr	2.08L/lbs/yr	15	$ 25,000.00	8%	Both	New/Retrofit
Commercial	New/Existing	Commercial Ozone Laundry Treatment	Ozone Treatment Washer extractor => 500 lbs	Commercial laundry with no ozone treatment system		0.0367 m3/lbs/yr	0.00213 kwh/lbs/yr	2.08L/lbs/yr	15	$ 31,000.00	8%	Both	New/Retrofit
Commercial	New/Existing	Commercial Ozone Laundry Treatment	Ozone Treatment Tunnel Washer <= 120 lbs	Commercial laundry with no ozone treatment system		0.0293 m3/lbs/yr	0.00150 kwh/lbs/yr	1.27 L/lbs/yr	15	$ 50,000.00	8%	Both	New/Retrofit
Commercial	New/Existing	Commercial Ozone Laundry Treatment	Ozone Treatment Tunnel Washer 121 lbs to 499 lbs	Commercial laundry with no ozone treatment system		0.0293 m3/lbs/yr	0.00150 kwh/lbs/yr	1.27 L/lbs/yr	15	$ 105,000.00	8%	Both	New/Retrofit
Commercial	New/Existing	Commercial Ozone Laundry Treatment	Ozone Treatment Tunnel Washer => 500 lbs	Commercial laundry with no ozone treatment system		0.0293 m3/lbs/yr	0.00150 kwh/lbs/yr	1.27 L/lbs/yr	15	$ 160,000.00	8%	Both	New/Retrofit
Commercial	Existing	Condensing Boiler - DHW (<100 Mbtu/h)	90% or greater AFUE	Non-condensing Boiler	82% AFUE	0.02170 /Btu/hr	0	0	25	$ 2,045.00	5%	Both	Replacement
Commercial	Existing	Condensing Boiler - DHW (100 to 199 Mbtu/h)	90% or greater AFUE	Non-condensing Boiler	82% AFUE	0.01332 /Btu/hr	0	0	25	$ 2,984.00	5%	Both	Replacement
Commercial	Existing	Condensing Boiler - DHW (200 to 299 Mbtu/h)	90% or greater AFUE	Non-condensing Boiler	82% AFUE	0.00996 /Btu/hr	0	0	25	$ 3,797.00	5%	Both	Replacement
Commercial	New	Condensing Boiler - DHW (<100 Mbtu/h)	90% or greater AFUE	Non-condensing Boiler	82% AFUE	0.02170 /Btu/hr	0	0	25	$ 1,475.00	5%	Both	New
Commercial	New	Condensing Boiler - DHW (100 to 199 Mbtu/h)	90% or greater AFUE	Non-condensing Boiler	82% AFUE	0.01332 /Btu/hr	0	0	25	$ 2,414.00	5%	Both	New
Commercial	New	Condensing Boiler - DHW (200 to 299 Mbtu/h)	90% or greater AFUE	Non-condensing Boiler	82% AFUE	0.00996 /Btu/hr	0	0	25	$ 3,227.00	5%	Both	New
Commercial	New/Existing	Condensing Gas Water Heater (1,000gal/day)	95% thermal efficiency	Conventional storage tank water heater	80% efficiency, 91 gal. tank.	1,551	0	0	13	$ 2,230.00	5%	Both	New/Replacement
Commercial	New/Existing	Condensing Gas Water Heater (100gal/day)	95% thermal efficiency	Conventional storage tank water heater	80% efficiency, 91 gal. tank.	332	0	0	13	$ 2,230.00	5%	Both	New/Replacement
Commercial	New/Existing	Condensing Gas Water Heater (500gal/day)	95% thermal efficiency	Conventional storage tank water heater	80% efficiency, 91 gal. tank.	873	0	0	13	$ 2,230.00	5%	Both	New/Replacement
Commercial	New	Drain Water Heat Recovery (DWHR)	Laundromat	No DWHR		49,735	0	0	25	$ 37,211.00	5%	Both	New
Commercial	New	Drain Water Heat Recovery (DWHR)	Entertainment, Arena	No DWHR		394 per Showerhead	0	0	25	$776 per Showerhead	5%	Both	New
Commercial	New	Drain Water Heat Recovery (DWHR)	University/College Cafeterias - Dishwashing	No DWHR		4.6 per Meal Served/Day	0	0	25	$3.41 per Meal Served/Day	5%	Both	New
Commercial	New	Drain Water Heat Recovery (DWHR)	Hospital - Dishwashing	No DWHR		12 per Bed	0	0	25	$11.88 per Bed	5%	Both	New
Commercial	New	Drain Water Heat Recovery (DWHR)	Hospital - Laundry	No DWHR		295 Per Bed	0	0	25	$250 per Bed	5%	Both	New
Commercial	New	Drain Water Heat Recovery (DWHR)	Nursing Home - Dishwashing	No DWHR		12 per Bed	0	0	25	$16.54 per Bed	5%	Both	New
Commercial	Existing	Drain Water Heat Recovery (DWHR)	Laundromat	No DWHR		49,735	0	0	25	$ 40,811.00	5%	Both	Retrofit
Commercial	Existing	Drain Water Heat Recovery (DWHR)	Entertainment, Arena	No DWHR		394 per Showerhead	0	0	25	$1209 per Showerhead	5%	Both	Retrofit
Commercial	Existing	Drain Water Heat Recovery (DWHR)	University/College Cafeterias - Dishwashing	No DWHR		11.6 Meal Served per Day	0	0	25	$6.26 per Meal Served per day	5%	Both	Retrofit
Commercial	Existing	Drain Water Heat Recovery (DWHR)	Hospital - Dishwashing	No DWHR		31 per Bed	0	0	25	$18.19 per Bed	5%	Both	Retrofit
Commercial	Existing	Drain Water Heat Recovery (DWHR)	Hospital - Laundry	No DWHR		295 per Bed	0	0	25	$274 per Bed	5%	Both	Retrofit
Commercial	Existing	Drain Water Heat Recovery (DWHR)	Nursing Home - Dishwashing	No DWHR		31 per Bed	0	0	25	$25.33 per Bed	5%	Both	Retrofit
Commercial	New/Existing	Energy Star Dishwasher	Undercounter – High Temperature	Non-Energy Star Dishwasher		142	1,790	20,371	10	$ 120.00	40%	Both	New/Replacement
Commercial	New/Existing	Energy Star Dishwasher	Undercounter – Low Temperature	Non-Energy Star Dishwasher		333	0	47,827	10	$ 50.00	40%	Both	New/Replacement

(shaded)	Indicates an update (March 2015) to Board-approved list of input assumptions

Target Market		Equipment Details				Annual Resource Savings			Other				
Sector	**New/Existing**	**Efficient Equipment**	**Details of Efficient Equipment**	**Base Equipment**	**Details of Base Equipment**	**Natural Gas (m3)**	**Electricity (kWh)**	**Water (L)**	**EUL**	**Incremental Cost ($)**	**Free Rider (%)**	**Utility Measure Applies to**	**Decision Type**
Commercial	New/Existing	Energy Star Dishwasher	Stationary Single Tank Door – High Temperature	Non-Energy Star Dishwasher		922	4,167	132,263	15	$ 770.00	20%	Both	New/Replacement
Commercial	New/Existing	Energy Star Dishwasher	Stationary Single Tank Door – Low Temperature	Non-Energy Star Dishwasher		2,120	0	304,205	15	$ -	20%	Both	New/Replacement
Commercial	New/Existing	Energy Star Dishwasher	Single Tank Conveyor – High Temperature	Non-Energy Star Dishwasher		560	4,247	80,303	20	$ 2,050.00	27%	Both	New/Replacement
Commercial	New/Existing	Energy Star Dishwasher	Single Tank Conveyor - Low Temperature	Non-Energy Star Dishwasher		1,712	0	245,631	20	$ -	27%	Both	New/Replacement
Commercial	New/Existing	Energy Star Dishwasher	Multi Tank Conveyor - High Temperature	Non-Energy Star Dishwasher		2,124	9,668	304,677	20	$ 970.00	27%	Both	New/Replacement
Commercial	New/Existing	Energy Star Dishwasher	Multi Tank Conveyor - Low Temperature	Non-Energy Star Dishwasher		2,469	0	354,276	20	$ 970.00	27%	Both	New/Replacement
Commercial	Existing	High Efficiency Boiler - DHW (<100 Mbtu/h)	85% or greater AFUE	Non-Condensing Boiler	82% AFUE	0.00468 /Btu/hr	0	0	25	$ 1,808.00	5%	Both	Replacement
Commercial	Existing	High Efficiency Boiler - DHW (100 to 199 Mbtu/h)	85% or greater AFUE	Non-Condensing Boiler	82% AFUE	0.00287 /Btu/hr	0	0	25	$ 2,114.00	5%	Both	Replacement
Commercial	Existing	High Efficiency Boiler - DHW (200 to 299 Mbtu/h)	85% or greater AFUE	Non-Condensing Boiler	82% AFUE	0.00215 /Btu/hr	0	0	25	$ 1,958.00	5%	Both	Replacement
Commercial	New	High Efficiency Boiler - DHW (<100 Mbtu/h)	85% or greater AFUE	Non-Condensing Boiler	82% AFUE	0.00468 /Btu/hr	0	0	25	$ 1,238.00	5%	Both	New
Commercial	New	High Efficiency Boiler - DHW (100 to 199 Mbtu/h)	85% or greater AFUE	Non-Condensing Boiler	82% AFUE	0.00287 /Btu/hr	0	0	25	$ 1,544.00	5%	Both	New
Commercial	New	High Efficiency Boiler - DHW (200 to 299 Mbtu/h)	85% or greater AFUE	Non-Condensing Boiler	82% AFUE	0.00215 /Btu/hr	0	0	25	$ 1,388.00	5%	Both	New
Commercial	Existing	Pre-Rinse Spray Nozzle	1.24 GPM	Standard pre-rinse spray nozzle	3.0 GPM	190 - 886**	0	36,484 - 170,326**	5	$ 60.00	12.40%	UG	Retrofit
Commercial	New	Pre-Rinse Spray Nozzle (Full Service)	0.64 GPM	Pre-rinse spray nozzle	3.0 GPM	1,286	0	252,000	5	$ 150.00	0%	EGD	New
Commercial	Existing	Pre-Rinse Spray Nozzle (Full Service)	0.64 GPM	Pre-rinse spray nozzle	3.0 GPM	1,286	0	252,000	5	$ 150.00	0%	Both	Retrofit
Commercial	Existing	Pre-Rinse Spray Nozzle (Full Service)	0.64 GPM	Pre-rinse spray nozzle	1.6 GPM	457	0	97,292	5	$ 150.00	0%	Both	Retrofit
Commercial	New	Pre-Rinse Spray Nozzle (Limited)	0.64 GPM	Pre-rinse spray nozzle	3.0 GPM	339	0	66,400	5	$ 150.00	0%	EGD	New
Commercial	Existing	Pre-Rinse Spray Nozzle (Limited)	0.64 GPM	Pre-rinse spray nozzle	3.0 GPM	339	0	66,400	5	$ 150.00	0%	Both	Retrofit
Commercial	Existing	Pre-Rinse Spray Nozzle (Limited)	0.64 GPM	Pre-rinse spray nozzle	1.6 GPM	90	0	19,197	5	$ 150.00	0%	Both	Retrofit
Commercial	New	Pre-Rinse Spray Nozzle (Other)	0.64 GPM	Pre-rinse spray nozzle	3.0 GPM	318	0	62,200	5	$ 150.00	0%	EGD	New
Commercial	Existing	Pre-Rinse Spray Nozzle (Other)	0.64 GPM	Pre-rinse spray nozzle	3.0 GPM	318	0	62,200	5	$ 150.00	0%	Both	Retrofit
Commercial	Existing	Pre-Rinse Spray Nozzle (Other)	0.64 GPM	Pre-rinse spray nozzle	1.6 GPM	109	0	23,166	5	$ 150.00	0%	Both	Retrofit
Commercial	New	Prescriptive Higher Efficiency Boiler - DWH	83-84% Efficient, 300-1500 MBH	DWH Boiler	80.5% Thermal Efficiency	1,168-4,693	0	0	25	$3900 -$5900	10/12/20%	Both	New
Commercial	New	Prescriptive Higher Efficiency Boiler - DWH	85-88% Efficient, 300-1500 MBH	DWH Boiler	80.5% Thermal Efficiency	1,861-7,475	0	0	25	$4500-$7400	10/12/20%	Both	New
Commercial	Existing	Prescriptive Higher Efficiency Boiler - DWH	83-84% Efficient, 300-1500 MBH	DWH Boiler	80.5% Thermal Efficiency	1,168-4,693	0	0	25	$3900 -$5900	10/12/20%	Both	Replacement
Commercial	Existing	Prescriptive Higher Efficiency Boiler - DWH	85-88% Efficient, 300-1500 MBH	DWH Boiler	80.5% Thermal Efficiency	1,861-7,475	0	0	25	$4500-$7400	10/12/20%	Both	Replacement
Commercial	New	Tankless Water Heater	100 USG/day, 84% thermal efficiency	Conventional Storage Tank Water Heater	80% thermal efficiency	154	0	0	18	-$ 1,102.00	2%	Both	New
Commercial	Existing	Tankless Water Heater	100 USG/day, 84% thermal efficiency	Conventional Storage Tank Water Heater	80% thermal efficiency	154	0	0	18	-$ 1,102.00	2%	Both	Replacement

Multi-Family Water Heating

Multi-Family	New/Existing	CEE Tier 2 Front-Loading Clothes Washer	MEF=2.20, WF=5.1	Conventional top-loading, vertical axis clothes washer	MEF=1.26, WF=9.5	117	396	58,121	11	$ 600.00	10%	Both	New/Replacement
Multi-Family	New/Existing	Energy Star Front-Loading Clothes Washer	MEF=1.72 ,WF=8.0	Conventional top loading vertical axis washers	MEF = 1.26, WF=9.5	76	201	19,814	11	$ 150.00	48%	UG	New/Replacement
Multi-Family	New/Existing	Faucet Aerator	Bathroom, 1.0 GPM	Standard flow bathroom aerator (code compliant)	2.2 GPM	6	0	2,501	10	$ 0.60	10%	Both	New/Retrofit
Multi-Family	New/Existing	Faucet Aerator	Bathroom, 1.5 GPM	Standard flow bathroom aerator (code compliant)	2.2 GPM	3.73	0	1459	10	$ 0.60	10%	Both	New/Retrofit
Multi-Family	New/Existing	Faucet Aerator	Kitchen, 1.0 GPM	Standard flow kitchen aerator (code compliant)	2.2 GPM	20	0	7,742	10	$ 1.14	10%	Both	New/Retrofit
Multi-Family	New/Existing	Faucet Aerator	Bathroom, 1.5 GPM	Standard flow bathroom aerator (code compliant)	2.2 GPM	3.73	0	1459	10	$ 0.60	10%	Both	New/Retrofit
Multi-Family	New/Existing	Low-Flow Showerhead - (MF ONLY)	1.25 GPM	Replace existing 2.0 GPM	2.0 GPM	24	0	7,933	10	$ 3.79	10%	UG	New/Retrofit

	Indicates an update (March 2015) to Board-approved list of input assumptions

Target Market		Equipment Details				Annual Resource Savings			Other				
Sector	New/Existing	Efficient Equipment	Details of Efficient Equipment	Base Equipment	Details of Base Equipment	Natural Gas (m3)	Electricity (kWh)	Water (L)	EUL	Incremental Cost ($)	Free Rider (%)	Utility Measure Applies to	Decision Type
Multi-Family	New	Low-flow showerhead (Distributed)	1.25 GPM	Average existing stock	2.2 GPM	32	0	9,585	10	$ 3.79	10%	UG	New
Multi-Family	Existing	Low-flow showerhead (Distributed)	1.25 GPM	Average existing stock	2.2 GPM	32	0	9,585	10	$ 3.79	10%	UG	Retrofit
Multi-Family	New	Low-flow showerhead (Distributed)	1.5 GPM		2.2 GPM	33	0	5,228	10	$ 6.00	10%	UG	New
Multi-Family	Existing	Low-flow showerhead (Distributed)	1.5 GPM	Average existing stock	2.2 GPM	33	0	5,228	10	$ 6.00	10%	UG	Retrofit
MultiFamily	New	Low-Flow Showerhead (Per household, Installed)	1.25 GPM		2.5 GPM	36	-	11,587	10	$ 12.50	10%	EGD	New
MultiFamily	New	Low-Flow Showerhead (Per household, Installed)	1.5 GPM		2.5 GPM	29	-	7,818	10	$ 12.50	10%	EGD	New
MultiFamily	Existing	Low-Flow Showerhead (Per household, Installed)	1.5 GPM	2.0 -2.5 GPM showerhead	2.25 GPM	21	0	5,931	10	$ 12.50	10%	EGD	Retrofit
MultiFamily	Existing	Low-Flow Showerhead (Per household, Installed)	1.5 GPM	2.6 -3.0 GPM GPM showerhead	2.8 GPM	40	0	10,036	10	$ 12.50	10%	EGD	Retrofit
MultiFamily	Existing	Low-Flow Showerhead (Per household, Installed)	1.5 GPM	3.1 - 3.5 GPM showerhead	3.3 GPM	58	0	13,621	10	$ 12.50	10%	EGD	Retrofit
MultiFamily	Existing	Low-Flow Showerhead (Per household, Installed)	1.5 GPM	3.6 GPM and above	3.6 GPM	69	0	15,705	10	$ 12.50	10%	EGD	Retrofit
MultiFamily	Existing	Low-Flow Showerhead (Per household, Installed)	2.0 GPM	2.0 -2.5 GPM showerhead	2.25 GPM	7.6	0	1913	10	$ 18.71	0%	EGD	Retrofit
MultiFamily	Existing	Low-Flow Showerhead (Per household, Installed)	2.0 GPM	2.6 -3.0 GPM GPM showerhead	2.8 GPM	26	0	5996	10	$ 18.71	0%	EGD	Retrofit
MultiFamily	Existing	Low-Flow Showerhead (Per household, Installed)	2.0 GPM	3.1 - 3.5 GPM showerhead	3.3 GPM	44	0	9559	10	$ 18.71	0%	EGD	Retrofit
MultiFamily	Existing	Low-Flow Showerhead (Per household, Installed)	2.0 GPM	3.6 GPM and above	3.6 GPM	55	0	11628	10	$ 18.71	0%	EGD	Retrofit

* Efficiency ratings and natural gas savings will vary by fireplace type. Please see substantiation sheet for type specific efficiency ratings and savings.

** Savings will vary for different segments. Please see substantiation sheet for segment specific savings.

Union Gas Custom Projects	
Sector	Free Rider (%)
Agriculture	54%
Industrial	54%
Commercial	54%
Multi-Residential	54%
New Construction	54%
Low-Income - Weatherization	0%
Low-Income - Custom	5%
Residential - Home Reno Rebate	15%

Enbridge Custom Projects	
Sector	Free Rider (%)
Agriculture	40%
Industrial	50%
Commercial	12%
Multi-Residential	20%
New construction	26%
Low-Income - Custom	0%
Residential - Community Energy Retrofit	15%

Enbridge Measure Life Assumptions for Custom Measures and Offerings

	Commercial	Industrial	Multi Residential
Boiler Related			
Boilers – DHW	25[2]	n/a	25[2]
Boilers - Industrial Process	n/a	20	n/a
Boilers – Space Heating	25[2]	25[2]	25[2]
Combustion Tune-up	5	5	n/a
Controls	15	15	15
Steam pipe/tank insulation	n/a	15	n/a
Steam trap	5[3]	5[3]	n/a
Building Related			
Building envelope	25	25	25
Windows	25	25	25
Greenhouse curtains	n/a	10	n/a
Double Poly greenhouse	n/a	5	n/a
HVAC Related			
Dessicant cooling	15	n/a	n/a
Heat Recovery	15	15	n/a
Infra-red heaters	10	10	n/a
Make-up Air	15	15	15
Novitherm panels	15	n/a	15
Furnaces (gas-fired)	18[4]	n/a	18[4]
Re-Commissioning	5[5]	n/a	5[5]
Process Related			
Furnaces (gas-fired)	n/a	18[4]	n/a
Measure Life for Residential and Low Income Offerings			
Enbridge Community Energy Retrofit – without furnace upgrade	25[6]		
Enbridge Community Energy Retrofit – with furnace upgrade	15[6]		
Enbridge Low Income Weatherization	25[7]		

[2] 2007 ASHRAE handbook, HVAC applications, I-P edition, Chapter 36 section 3, Table 4 (Comparison of Service Life Estimates).
[3] Enbridge Gas Distribution Independent Audit of 2010 DSM Program Results, June 30, 2011, p. 54.
[4] 2007 ASHRAE handbook, HVAC applications, I-P edition, Chapter 36 section 3, Table 4 (Comparison of Service Life Estimates).
[5] "Measure Life for Retro-Commissioning and Continuous Commissioning Projects", Finn Projects. December 31, 2008.
[6] Endorsed by Enbridge Audit Committee, February 2014. Applicable to 2014 results only.
[7] Endorsed by the Technical Evaluation Committee, February 13, 2014

Union Gas Effective Useful Life for Custom Project Measures[8]

Equipment Type	Sector	EUL	
		Years	Source
Boilers			
Industrial Process - greater than 2500 MBHp	Industrial	20	2
Space heating - Under 300 MBHp	Commercial & Multi-Residential	20*	4
Space heating - 300 to 2500 MBHp	Commercial & Multi-Residential	20*	4
Domestic Hot Water	Commercial & Multi-Residential	20*	4
Controls	All	20*	
Combustion Tune-Up	Industrial & Commercial	1	
Air Makeup (line)	Industrial	20	
Oxy-Fuel	Industrial	20	
Low NOx Boiler	Industrial	20	
Building Optimization			
Building Optimization Program - Behavioral Savings Project	Commercial	5	3
Economizers			
New with boiler - conventional and condensing	Industrial & Commercial	20	
Retrofit - conventional and condensing	Industrial & Commercial	10	2
Repair	Industrial & Commercial	5	2
Electronic Burner Controls			
Linkage-Less Controls, Modulating Motors, Mod Motors		20	
Agriculture			
IR Poly	Greenhouse	4	
Energy Curtains	Greenhouse	5	1
Grain Dryer	Commercial	20	5

[8] Where site specific information or a relevant prescriptive EUL is available to support an alternate EUL value for a specific custom project, Union Gas will use the alternate value for that custom project."

HVAC

Air Curtains (single and double door)	Commercial	15	2
Building Automation System - New	Commercial	15	2
Cooling tower for HVAC systems	Commercial	15	1
Combustion Tune-Up	Industrial & Commercial	1	5
Demand Control Ventilation	Commercial & Multi-Residential	15	5
Dessicant Cooling	Commercial	15	6
Exhaust Fan Controls	Commercial	15	5
Heat Recovery	Industrial & Commercial	15	
Infiltration Controls - Dock Seals, Air Doors	Commercial	15	2
Make-Up Air	All	15	
Novitherm panels	Commercial & Multi-Residential	15	
VFD retrofit on MUA	Commercial & Multi-Residential	10	
Turndown controls on Modulating Boiler	Commercial	20	5

Heat Exchangers

Plate - Plate or Tube-Tube	Industrial & Commercial	14	2
Air -Air	Commercial	14	2

Insulation

Roof/Ceiling insulation	Industrial & Commercial	20	2
Outside Pipe - exposed to the environment, properly protected	Industrial & Commercial	20	
Building Weatherization - Air sealing	Commercial	15	1
Tank Exterior Insulation	Industrial & Commercial	15	2

Ovens and Thermal oxidizers

Low Temperature (less than 300°C)	Industrial	20	
Medium Temperature (300°C - 1000°C)	Industrial	20	
High Temperature (>1000°C)	Industrial	15	

Process Controls

Electronic Loop Controllers	Industrial	20	
PLC's	Industrial	20	
Flame Supervision (relays)	Industrial	20	
Flame Detectors (UV-Flame Rods)	Industrial	5	

Steam Distribution

Steam Traps	Industrial & Commercial	7	
Steam Piping Leaks	Industrial & Commercial	20	5
Steam Valve	Industrial Food Services	5	5, 8

Water Conditioners

Reverse Osmosis (RO)	Industrial	20	
Ion Exchange	Industrial	20	

References

*	Useful Life estimates are most dependent on the application and quality of maintenance. Any equipment life that was reported higher than 20 years was reduced to 20 years to conform to Union Gas's 20 year limit.
1	2011 Commercial Opportunity Screening Report May 02 2011, Navigant for Union Gas
2	DEER EUL Summary 2010-1-08
3	Measure Life for Retro-Commissioning and Continuous Commissioning Projects, Finn Projects for Enbridge
4	ASHRAE
5	Union Gas 2010 DSM Annual report filing
6	Enbridge Approved IA
7	2011 Commercial Hydronic Boiler System Baseline Study, ICF Marbek for Enbridge
8	Confirmation of high quality feed water required for 10 year life

Union Gas Effective Useful Life for Custom Residential/ LI Project Measures

Effective Useful Life for Residential / Low Income Offerings	
Union Gas Home Reno Rebate – without furnace upgrade	25[9]
Union Gas Home Reno Rebate – with furnace upgrade	15[8]
Union Gas Low Income Weatherization – Attic Insulation	25[7]
Union Gas Low Income Weatherization – Basement Insulation	25[7]
Union Gas Low Income Weatherization – Wall Insulation	25[7]
Union Gas Low Income Weatherization – Draft Sealing	25[7]

Where site specific information or a relevant prescriptive Equipment Useful Life (EUL) is available to support an alternate EUL value for a specific custom project (Union / Enbridge) will use the alternate value for that custom project.[10]

[9] Union Gas Independent Audit of 2012 DSM Program Results. Applies to 2014 results only.
[10] EB-2012-0441; Exhibit B, Tab 1, Schedule 3

NEW AND UPDATED

SUBSTANTIATION DOCUMENTS

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RESIDENTIAL AND LOW INCOME 1.0 AND 1.5GPM FAUCET AERATORS

DATE: **NOVEMBER 3, 2014**

TO: Ontario TEC Sub-Committee

FROM: ERS

RE: **TRM SECTION – RESIDENTIAL AND LOW INCOME 1.0 AND 1.5 GPM FAUCET AERATORS**

The following TRM measure covers

Residential → 1.0 and 1.5 GPM Faucet Aerators→ All Measure Categories

Low Income → 1.0 and 1.5 GPM Faucet Aerators→ All Measure Categories

The section addresses the installation of 1.0 and 1.5 GPM bathroom and kitchen faucet aerators in residential dwellings. Background information reviewed by ERS for this measure includes but is not limited to:

- Showerheads/Aerators Flow Rate Validation – Project # 228408 – presented to Enbridge Gas Distribution - Natural Gas Technologies Centre – December, 10, 2007.
- Resource Savings Values in Selected Residential DSM Prescriptive Programs – Submitted to Union Gas and Enbridge Gas – Summit Blue Consulting, LLC – June 23, 2008
- Review comments regarding Navigant Draft Measure Characteristics - Vermont Energy investment Corporation - March 2009.
- Measures and Assumptions for DSM Planning – Presented to the Ontario Energy Board – Navigant - April 16, 2009.

- US EPA WaterSense website. - www.epa.gov/watersense.

- *US DOE Federal Energy Management Planning – Energy Cost Calculator for Aerators and Showerheads.*

- *Similar TRM sections from TRM for the states of Delaware, Indiana, Illinois, and Ohio.*

Existing substantiation sheets reflecting the installation of both 1.5 GPM and 1.0 GPM aerators were provided. The 1.5 GPM faucet aerator is reflected in the U.S. Department of Energy Best Practices Guide and is the most commonly offered by other programs. This TRM reflects deemed water and natural gas savings values resulting from the installation of either 1.0 or 1.5 GPM aerators.

Water and natural gas savings resulting from these measures are dependent on the baseline flow rate and human behavior and will very significantly from site to site.

The baseline condition reflected in this TRM reflects the maximum flow condition required by the Ontario Building Code and is consistent with the maximum flow allowed for aerators manufactured or sold in the United Sates after January 1, 2014. This is the appropriate baseline for new construction it is believed to represent a reasonable approximation of the current average baseline condition for existing homes.

Typical consumption and usage pattern values are taken from several studies that have previously been completed. These values are based on empirical data from finite sample sizes, and thus have a relatively high degree of uncertainty. It is our belief that the values used and the resulting deemed savings values are representative of typical conditions.

The reference resources used to estimate the affected hot water use per faucet (faucet use per capita, people per household, and the percent flow factors) either do not distinguish between residential and low income homes or expressly combine them, so the residential and low income savings estimates are the same.

1.5 GPM Faucet Aerators – Bathroom and Kitchen - Retrofit

Version Date and Revision History	
Draft date	11/3/2014
Version history	v.1
Effective date	TBD
End date	N/A
Residential → 1.0 and 1.5 GPM Faucet Aerators Bathroom and Kitchen → All Measure Categories Low Income → 1.0 and 1.5 GPM Faucet Aerators Bathroom and Kitchen → All Measure Categories	

Table 1 provides a summary of the key measure parameters with a deemed savings coefficient.

Table 1. Measure Key Data

Parameter	Definition		
Measure category	All Measure Categories		
Baseline technology	Standard flow bathroom and kitchen aerators	2.2 GPM (8.35 lpm)	
Efficient technology	Low flow bathroom and kitchen aerators.	1.0 GPM (3.8 lpm)	1.5 GPM (5.7 lpm)
Market type	Residential and multiresidential, including low income		
Annual water savings 1.0 GPM aerator	Bathroom aerator 2,501 Liters (661 gallons)	Kitchen aerator 7,742 liters (2,045 gallons)	
Annual water savings 1.5 GPM aerator	Bathroom aerator 1,459 Liters (385.4 gallons)	Kitchen aerator 4,516 Liters (1,193 gallons)	
Annual natural gas savings 1.0 GPM aerator	Bathroom aerator 6.40 m^3	Kitchen aerator 19.82 m^3	
Annual natural gas savings 1.5 GPM aerator	Bathroom aerator 3.73 m^3	Kitchen aerator 11.56 m^3	
Measure life	10 years		
Incremental cost	$1.14 – Kitchen $0.60 - Bathroom		
Restrictions	Existing residential homes with natural gas fired water heaters		

OVERVIEW

The measure consists of installing either 1.0 or 1.5 GPM aerators on bathroom and kitchen faucets in residential dwellings. The aerators are provided to the dwelling occupants at no cost by the participating utility.

Reduction in water and natural gas consumption result from the measure. 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 and are referenced in this document.

APPLICATION

This measure applies to the installation of 1.0 and 1.5 GPM bathroom faucet aerators in the residential settings. The measure is applicable to retrofit installation in existing facilities with natural gas fueled domestic water heating. The measure is also applicable to new construction with distribution through participating building contractors.

BASELINE TECHNOLOGY

The baseline technology is defined as an aerator with a flow rate of 2.2 GPM (8.3 lpm). This value is reflected in the Ontario Building Code and is consistent with the maximum allowable flow rate for all faucet aerators manufactured or sold in the United States after Jan 2014, as specified by US Energy Policy Act of 1992. [1]

Table 2. Baseline Faucet Aerators

Type	Maximum Flow Rate
Code compliant faucet aerator	2.2 GPM (8.35 lpm)

EFFICIENT TECHNOLOGY

The high efficiency technology is a low flow aerator with a rated flow of 1.5 GPM (5.7 lpm) or less at a water pressure of 60 psi. [2]

Table 3. Efficient Faucet Aerator

Type	Maximum Flow Rate
Low flow faucet aerator	1.5 GPM (5.7 lpm)

ENERGY IMPACTS

This measures results in a reduction in water and natural gas consumption. The reduction in -water consumption is a function of the baseline and efficient flow rates and typical per capita use patterns. Natural gas savings are dependent upon these factors, the % of the flow reduction represented by heated water, typical entering and leaving hot water temperatures, and water heater efficiencies.

SAVINGS ALGORITHMS

The measure savings are calculated using the following algorithms:

$$W_{savings} = Fu \times Ppl \times Dr\% \times Fa\% \times \left(\frac{Fl_{base} - Fl_{eff}}{Fl_{base}}\right) \times 3.78 \frac{liters}{gallon} \times 365 \frac{days}{year}$$

Where,

$W_{savings}$	=	Annual Water Savings (liters)
Fu	=	Faucet use per capita (gallons)
Ppl	=	Number of people per household
Dr %	=	Percentage of flow that goes straight down the drain (%) This is the proportion of water use that depends on faucet on-time, such as when rinsing a toothbrush, as opposed to being dependent on the volume of water drawn, such as when filling a basin.
Fa %	=	Single faucet use (bathroom or kitchen) as a % of total household faucet use (%)
Fl_{base}	=	Rated flow of baseline equipment (GPM)
Fl_{eff}	=	Rated flow of efficient equipment (GPM)

Once the reduction in water consumption is determined for each aerator, deemed natural gas savings can be calculated using this water savings value and the following formula.

$$NG_{savings} = W_{savings} \times 8.33 \frac{BTU}{gallon - °F} \times \%_{hot} \times (T_{out} - T_{in}) \times \frac{\left(\frac{1}{RE}\right)}{35{,}738\ BTU\ per\ m^3}$$

Where,

$NG_{savings}$	=	Annual deemed natural gas savings (m^{3})
$W_{savings}$	=	Annual deemed water savings from equation above (gallons/year)
$\%_{hot}$	=	% of aerator flow that is heated by water heater
T_{out}	=	Water temperature leaving the water heater (°F)

T_{in} = Water temperature entering the water heater (^{0}F)

RE = Water heater recovery efficiency factor (%)

LIST OF ASSUMPTIONS

The assumptions used to calculate the deemed savings coefficients are shown in Table 4.

Table 4. Assumptions List

Parameter	Description	Value	Source
Fu	Faucet use per capita	10.9 gallons / day (41.29 liters / day)	[3]
Ppl	Average people per household	2.9 people per household	Common Assumptions
Dr %	Percentage of flow that goes directly down the drain[1]	70% - bathroom 50% - kitchen	[4]
Fa %	The percentage to total faucet flow represented by each faucet	15% bathroom (per faucet) 65% kitchen faucet	[4]
T_{in}	Average temperature of entering cold water	9.4ºC (48.9 ºF)	Common Assumptions
T_{hot}	Average temperature of heated hot water	-48.9C (120 ºF)	Common Assumptions
$\%_{hot}$	% of aerator flow that is heated	46%	[5] [6]
RE	Water heater recovery efficiency factor (standard unit)	78.7%	Common Assumptions

SAVINGS CALCULATION EXAMPLE

Inserting values from the list of assumptions provided in Table 4 into the water savings equation above leads to a deemed water consumption reduction for a single 1.5 GPM bathroom aerator of:

[1] There is no research data on the percentage of water that flows straight down the drain. Assuming that it's probably not all straight down the drain nor is it all batch use for kitchen faucets, a range of 25% to 75% was assumed with 50% as the point estimate. For bathroom faucets, one would expect less batch use than in the kitchen, but not 0% so the range was set from 50% to 90% straight down the drain, with 70% as the point estimate.

10.9 gallon/day per person × 2.9 people × 70% × 15% × (2.2 – 1.5) / 2.2) × 365 days/year × 3.785 liters/gallon = **1,459 liters/year** (385.4 gallons per year)

Inserting the deemed water savings value, temperatures and water heater recovery efficiency into the natural gas savings equation leads to deemed annual natural gas savings of:

385.4 gallons / year × 46% heated water × 8.33 BTU / gallon - °F × (120 - 48.9) ^{0}F / 78.68% / 35,738 BTU/m^3 = **3.73 m^3 natural gas**

USES AND EXCLUSIONS

To qualify for this measure aerators must meet the maximum flow requirement listed in Table 3, and be installed in new or existing residential dwellings equipped with natural gas fueled water heaters.

MEASURE LIFE

The measure life attributed to this measure is 10 years. [7]

INCREMENTAL COST

Table 5 presents the measure incremental cost.

Table 5. Measure Incremental Cost

Boiler Rated Input (Btu/h)	Incremental Cost ($) [8]
High Efficiency Aerator	$1.14 – Kitchen $0.60 - Bathroom

The cost is equipment cost associated with bulk purchases by the participating utility for direct distribution to residential end users.

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Residential and Low Income Water Heating – Pipe Wrap - Retrofit

DATE: 3/3/2015

TO: Ontario TEC Committee

FROM: ERS

RE: Residential and Low Income Water Heating – Pipe Wrap

The following TRM measure covers insulated Pipe Wrap for residential water heating applications. We have reviewed the documentation provided to us by the TEC, and we have verified the accuracy of the engineering algorithms and reasonableness of the assumptions. In addition, we have researched the references provided and have investigated and referenced available sources of information.

The presented method is a simplified approach using commonly recognized relationships and parameters to accommodate industry standard marketing practice. 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. We believe the net effects of the simplifications offset each other within the range of accuracy of the estimate and the savings is a reasonable deemed value.

Residential → Water Heating → Retrofit→ Pipe Wrap
Low Income → Water Heating → Retrofit→ Pipe Wrap

Pipe Wrap– Retrofit

Version Date and Revision History	
Draft date	3/3/2015
Version history	v.1
Effective date	TBD
End date	N/A
Residential → Water Heating → Retrofit → Pipe Wrap Low Income → Water Heating → Retrofit→ Pipe Wrap	

Table 1 provides a summary of the key measure parameters with a deemed savings coefficient.

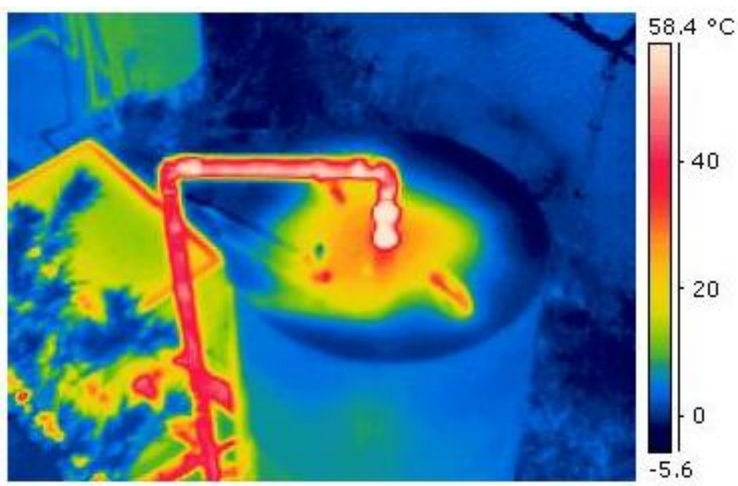
Table 1. Measure Key Data

Parameter	Definition
Measure category	Retrofit
Baseline technology	No existing pipe wrap
Efficient technology	Pipe wrap
Market type	Residential
Annual natural gas savings	Natural gas savings = 4.72 m^3/ft.
Measure life	15 years [1]
Restrictions	This measure is restricted to retrofit installations in residential homes. The savings are applicable for pipe wrap of up to two meters (6.56 ft) in length.

OVERVIEW

This measure provides the gas savings estimate and costs of insulating hot water pipes for conventional gas hot water storage tanks in a residential retrofit type of application. Figure 1 illustrates the heat loss phenomenon. Natural gas savings are calculated using an engineering algorithm and are reported in meters cubed per linear foot (m^3/ft).

Figure 1: Temperature of Hot Water Pipe Exiting Water Heater[1]



[1] Photograph by Dylan Pankow. Downloaded from https://www.flickr.com/photos/cbcthermal/1475767378/in/photostream/ on 8/1/2014.

BASELINE TECHNOLOGY

The baseline case is a hot water pipe without pipe wrap insulation. The R-value is shown in Table 2.

Table 2. Baseline without Pipe Wrap

Type	Value
No Pipe Wrap	R-0.43 [2]

This value is based on the heat transfer between water and air through copper with a heat transmission coefficient (U) of 2.3 Btu/ft²·°F·h.

EFFICIENT TECHNOLOGY

The energy efficient case is a hot water pipe with pipe wrap insulation. The R-value of the pipe wrap is shown in Table 3.

Table 3. Energy Efficient Pipe Wrap

Type	Value
Pipe Wrap	R-3.375 [3]

This value is based on a nominal ½-inch diameter copper pipe with ½-inch polyethylene insulation.[2]

ENERGY IMPACTS

Natural gas savings are achieved due to the difference in thermal resistance (R) between the energy efficient pipe wrap and the baseline condition of zero pipe wrap. The insulated pipe wrap reduces the rate of heat flow between the hot water in the pipe and the ambient air surrounding the pipe. This reduction of heat loss with insulated pipes can raise water supply temperature 1.1 ˚C-2.2 ˚C (2°F–4°F) [4] as compared with uninsulated pipes.

NATURAL GAS SAVINGS ALGORITHMS

The following algorithm is referenced from the Home Energy Services Impact Evaluation [5] and was used to calculate the stipulated gas impact. The total annual gas savings per linear foot, *S*, is calculated based on the difference in R values as shown in Table 4 below.

[2] The cited reference is web available and includes the material conductivity. The equivalent R-value can be calculated from radial heat loss equation and was also provided in a separate company spec sheet of the same name and title as the cited spec sheet, but that is not available on line.

$$S = \frac{\left[\left(\frac{1}{R_{pre}} - \frac{1}{R_{post}}\right) \times C_{pipe} \times \left(T_{pipe} - T_{amb}\right) \times 8760 \times TRF\right]}{RE \times 35{,}738 \frac{Btu}{m^3}}$$

where,

S = Annual gas savings (m³/ft)

R_{pre} = R-value of baseline equipment (ft²·°F·h/Btu), see Table 4

R_{post} = R-value of efficient equipment (ft²·°F·h/Btu), see Table 4

C_{pipe} = Circumference of the outlet water pipe (ft), see Table 4

T_{pipe} = Temperature of the outlet water pipe (°F), see Table 4

T_{amb} = Ambient air temperature (°F), see Table 4

TRF = Thermal regain factor, which discounts savings because reducing heat loss to conditioned space in the heating season is not beneficial, see Table 4[3]

$$TRF = \left[1 - \left(Regain \times \frac{Heating\ Hours\ per\ Year}{Total\ Hours\ per\ Year}\right)\right]$$

RE = Water heater recovery efficiency, see Table 4

LIST OF ASSUMPTIONS

Table 4 provides a list of assumptions utilized in the measure savings algorithm to derive the stipulated savings values listed in Table 1 above. It is assumed the savings are applicable for pipe wrap of up to a maximum length of two meters (6.56 ft) after which the savings per foot would be expected to significantly diminish.

Table 4. General Assumptions

Variable	Definition	Value	Source/Comments
R_{pre}	R-value of baseline equipment	0.435 ft²·°F·h/Btu	[2]
R_{post}	R-value of efficient equipment	3.810 ft²·°F·h/Btu	Sum of baseline equipment R and pipe wrap R. [3]
C_{pipe}	Circumference of	0.164 ft	Based on copper pipe with ½-inch

[3] Regain is a function of both space type and insulation level. Adding insulation to pipes in fully conditioned space with thermostatically controlled heating systems saves no energy in the heating season because the water heater waste heat offsets heating system energy (Regain=100%). While most water heaters are located within insulated space in Ontario, no data was found on the proportions of them in spaces heated with thermostatically controlled systems versus those in unconditioned or semi-conditioned space. In lieu of this the average value calculated for Massachusetts in [5] was used. For simplification, the analysis does not consider interactive effects with semi-conditioned spaces warmed with electric resistance spot heaters.

Variable	Definition	Value	Source/Comments
	outlet water pipe		nominal 5/8-inch actual outside diameter [3]
T_{pipe}	Temperature of outlet water pipe	130°F (54.4˚C)	Common assumptions table (no heat trap)
T_{amb}	Ambient air temperature	67.5°F (19.7˚C)	[6]
$Regain$	Regain	0.58	[5]
RE	Water heater recovery efficiency	0.79	Common assumptions table
	Conversion from Btu to m^3	35,738 Btu/m^3	Common assumptions table
	Hours per year	8,760	
	Heating Hours per year	4,058	Common assumptions table

Savings Calculation Example

The example below illustrates how the deemed savings value is determined for a pipe wrap retrofit installation on a residential hot water heater. For this example, it will be assumed that the equipment is sized for installation in a household size of 3, which is the average household size in Ontario.

$$S = \frac{\left[\left(\frac{1}{0.435} - \frac{1}{3.81}\right) \times 0.164 \times (130 - 67.5) \times 8760 \times \left[1 - \left(0.58 \times \frac{4,058}{8,760}\right)\right]\right]}{0.79 \times 35,738}$$

$$Annual\ NG\ savings = 4.72\ m^3/ft$$

Measure Life

The measure life is 15 years [1].

Incremental Cost

The average approximate incremental cost, assuming homeowner installation, of pipe wrap on a hot water outlet pipe is approximately $0.25 per foot [7].

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High Efficiency Gas Storage Water Heaters – New Construction

DATE: 3/12/14

TO: Ontario TEC Committee

FROM: ERS

RE: High Efficiency Gas Storage Water Heaters – New Construction

Residential → High Efficiency Gas Storage Water Heaters → New Construction

High Efficiency Gas Storage Water Heaters – New Construction

Version Date and Revision History	
Draft date	2/14/2014
Version history	v.1
Effective date	TBD
End date	N/A
Residential → High Efficiency Gas Storage Water Heaters → New Construction	

Table 1 provides a summary of the key measure parameters with a deemed savings coefficient.

Table 1. Measure Key Data

Parameter	Definition	
Measure category	New Construction (NC)	
Baseline technology	ENERGY STAR power vented storage tank water heater	Energy factor of 0.67
Efficient technology	High efficiency storage tank water heater	Energy factor of 0.80
Market type	Residential	
Annual natural gas savings	Natural gas savings = 68.3 m^3	
Measure life	16 years [1]	

Parameter	Definition
Incremental cost	$540
Restrictions	This measure is restricted to new construction installations in residential homes.

OVERVIEW

This measure is for the installation of a new high efficiency gas storage water heater in the case of residential new construction.

There are two major categories of water heating equipment for domestic use: storage water heaters, which keep a supply of hot water in a tank, and those that do not store hot water and only heat water when it is needed.

Gas storage water heaters can further be differentiated by natural draft or power vented flue gas exhaust. A power vent is a fan that speeds the exhaust of combustion gases, which increases efficiency, which increases overall performance but requires additional capital cost. An ENERGY STAR power vent storage water heater is considered the baseline for this measure.

Storage water heaters have a lower capital cost than on-demand water heaters, but they also have standby heat losses associated with continuously maintaining water stored at high temperatures. Higher efficiency storage water heaters have tanks with generous amounts of insulation to reduce these losses and more efficient gas burners than standard efficiency storage water heaters.

APPLICATION

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.

Gas storage water heaters are performance rated using an energy factor (EF). The EF is a measure of efficiency and it can be defined as the total energy delivered as hot water divided by the total energy consumed by the water heater over a 24-hour period in simulated use.

These ENERGY STAR units have an EF of 0.67 and the ability to produce at least 67 US gallons per hour of hot water after warm-up. This measure is intended to provide an incentive to install the highest efficiency power vented water heaters with an EF of 0.80 or greater. The energy consumption of high efficiency water heaters is calculated based on the daily and annual water consumption of a household (according to the number of people in the household) extrapolated from a hot water consumption research study undertaken by Natural Resources Canada (NRCan) [2]. Tank volume capacity requirements are associated with the number of occupants and what is standard issue according to the manufacturers, e.g., a typical family of three to four people would warrant a 50-US gallon tank in order to meet the hot water demand for the household.

Baseline Technology

For the new construction market, the ENERGY STAR rated power vented storage water heaters are considered baseline because experience indicates that this is a popular choice amongst homebuilders todayin order to achieve an efficiency level that falls within the OBC SB-12 required compliance path as referenced in Table 2.1.1.2.A of that supplementary standard. [3] [4] A gas storage water heater with a minimum EF to qualify for ENERGY STAR is shown in Table 2.

Table 2. Baseline Gas Storage Water Heater

Type	Water Heater Input (Btu/hr)	EF
Gas storage water heater	<75,000	0.67

Efficient Technology

A high efficiency gas storage heater with a minimum energy factor is shown in Table 3.

Table 3. New Gas Storage Water Heater Minimum Efficiency Requirements

Type	Water Heater Input (Btu/hr)	Minimum EF
Gas storage water heater	<75,000	0.80

Energy Impacts

Natural gas savings are achieved due to the difference in efficiencies between a high efficiency option and the baseline efficiency gas storage water heaters. The higher-efficiency equipment is typically able to both heat and store hot water more efficiently than the standard equipment.

There is a small amount of electrical savings for this measure, which have been shown to be negligible (<1 kWh annually) in the calculations.

Natural Gas Savings Algorithms

The following algorithms are referenced from the DOE Water Heater Analysis Model (WHAM) [5] and were used to calculate the stipulated gas impact in cubic meters per year and electric impact in kWh per year.

The total annual energy consumption for the water heater, Q_{In}, is calculated with the inlet water temperature specific to Ontario installations derived from the reference provided in Table 4 below. The total annual natural gas consumption of the water heater is the total annual energy consumption of the unit converted from British thermal units (Btus) to meters cubed.

The energy consumption of the high efficiency water heaters is calculated based on the daily and annual water consumption of a household (according to the number of people in the household) extrapolated from a hot water consumption research study undertaken by NRCan [6]. Tank volume capacity requirements are associated with the number of occupants and what is standard issue according to the manufacturers, e.g., a typical family of three to four people would warrant a 50-US gallon tank in order to meet the hot water demand for the household.

$$Q_{Out} = \rho \times V \times C_P \times (T_F - T_I)$$

where,

- Q_{Out} = Energy required to heat tap water to tank temperature (Btu/day)
- ρ = The density of water (lb/gal), see Table 4 below
- V = The daily drawn water (gal/day), see Table 4
- C_P = The specific heat of water (Btu/lb °F), see Table 4
- T_F = The water tank temperature (°F), see Table 4
- T_I = The inlet water temperature to the water heater (°F), see Table 4

$$Q_{In} = 365 \times (\frac{Q_{Out}}{RE} + UA \cdot (T_{Tank} - T_{Amb}) \times \left(24 - \frac{Q_{Out}}{RE \cdot P_{On}}\right))$$

where,

- Q_{In} = The total annual water-heater energy consumption (Btu/year)
- Q_{Out} = Energy required to heat tap water to tank temperature (Btu/day)
- RE = Recovery efficiency, see Table 4
- UA = Standby heat-loss coefficient, see Table 4
- T_{Tank} = Average tank temperature (°F), see Table 4
- T_{Amb} = Ambient air temperature (°F), see Table 4
- P_{On} = Water heater input rate (kBtu/hr), see Table 4

$$Annual\ NG\ consumption = Q_{In}$$

$$Annual\ NG\ savings = Annual\ NG\ consumption\ (baseline) - Annual\ NG\ consumption\ (high\ efficiency)$$

LIST OF ASSUMPTIONS

Table 4 provides a list of assumptions utilized in the measure savings algorithms to derive the stipulated savings values listed in Table 1 above. The algorithms are provided in the following section.

Table 4. General Assumptions

Variable	Definition	Inputs: Base Efficiency	Inputs: High Efficiency	Source/Comments
	Average household size	3		Common assumptions table
C_p	Specific heat of water (Btu/lb ˚F)	1.00		Common assumptions table
ρ	Water density (lb/gal)	8.30		Common assumptions table
V	Daily drawn water (US gallons)	42		[8]
RE	Recovery efficiency	0.78	0.90	[9]
UA	Standby heat-loss coefficient	5.78		[5]
T_{Amb}	Ambient air temperature	67.5°F (19.7˚C)		[7]
T_{In}	Inlet water temperature	48.9°F (9.39˚C)		Common assumptions table
T_{Tank}	Average tank temperature	120°F (48.9˚C)		Common assumptions table
P_{on}	Water heater input rate (kBtu/hr)	44.89	40.00	[9]
	Tank size (US gallons)	50		[8]
	Energy density of natural gas	35,738 m^3/Btu		Common assumptions table

SAVINGS CALCULATION EXAMPLE

The example below illustrates how the deemed savings value is determined for a retrofit installation of a high efficiency storage tank hot water heater. For this example, it will be assumed that the equipment is sized for installation in a household size of three, which is the average household size in Ontario.

Q_{out} can be calculated with actual values for the daily drawn water volume and inlet temperature, but similarly to above. This value is the same for both the baseline and the high efficiency technology:

$$Q_{Out} = 8.30 \times 30 \times 1.00 \times (120°F - 48.9°F) = 17{,}442\ Btu$$

Using Q_{Out}, the total annual water heater energy consumption can be calculated as Q_{In} for both the baseline and the high efficiency equipment:

$$Q_{In\ base} = 365/1000 \times \left(\frac{17{,}442}{0.784} + 5.78 \times (120°F - 67.5°F) \times \left(24 - \frac{17{,}442}{0.784 \cdot 44{,}894}\right)\right) = 14{,}145\ kBtu$$

Similarly,

$$Q_{In\ HE} = 11{,}724\ kBtu$$

Now the Q_{In} for the baseline and high efficiency technology can be subtracted and converted to meters cubed of natural gas savings.

$$Annual\ NG\ savings = 14{,}145 - 11{,}724 = 2{,}420\ kBtu$$

$$Annual\ NG\ savings = 2{,}420\ kBtu \times \frac{1{,}008}{35{,}738} = 68.3\ m^3$$

USES AND EXCLUSIONS

This measure requires that the gas storage water heaters be of a nominal input of 75 KBtu/hr or less and also be of the highest power vented efficiency or at least 0.80 EF.

MEASURE LIFE

The measure life is 16 years [1].

Residential high efficiency water heaters have a highly variable life expectancy because maintenance and water quality factors, such as hardness, can have a great effect on the equipment's lifetime [10] [11]. Most water heaters used in the Enbridge and Union areas are provided through water heater rental businesses and are therefore constructed of higher durability than standard units for purchase. This measure is also for the highest-efficiency units, which will have a more durable construction than standard units. Considering this, the lifetime referenced, though it's at the high end for typical residential units, is deemed appropriate.

INCREMENTAL COST

The average approximate incremental cost, including installation, for a 40 to 50 US-gallon storage tank water heater is $540[1].

Note: At this point there is only one manufacturer of water heaters that meet the high efficiency criteria, but the units are sold under different trade names.

[1]Costs estimated and averaged for qualifying models using Home Depot, Menards, and Warners' Stellian websites.

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Commercial ENERGY STAR Fryer - New Construction and Time of Natural Replacement

DATE: 12/03/2014

TO: Ontario TEC Committee

FROM: ERS

RE: ENERGY STAR Fryer

This TRM section is based on the review and validation of information provided in the substantiation sheet supplied by the TEC, the current documentation available from the Food Service Technology Center and the ENERGY STAR documentation presented on the Natural Resources Canada website.

This document results from the review of the above referenced documentation and provides a single TRM section addressing ENERGY STAR fryers.

ENERGY STAR FRYER

Version Date and Revision History	
Draft Date:	12/03/2014
Effective Date:	TBD
End Date:	TBD
Commercial →ENERGY STAR Fryer →New Construction/Time of Natural Replacement→ Food Service	

Table 1 provides a summary of the key measure parameters.

Table 1. Measure Key Data

Parameter	Definitions
Measure Category	New Construction (NC) Time of Natural Replacement (TNR)
Base Technology	A non-ENERGY STAR rated fryer
Efficient Technology	An ENERGY STAR rated fryer
Market type	All commercial and institutional buildings providing food service
Annual Natural Gas Savings (per vat)	1,408 m^3
Measure Life	12 years
Incremental Cost	$3,405

OVERVIEW

Fryers are used in commercial and institutional food service preparation for frying food in heated oil. Though fryers are available in a range of configurations, with the exception of specialized fryers for specific food items, they share a common design. The food is immersed in a kettle that holds the oil, which is typically heated by atmospheric or infrared gas burners underneath the kettle, or via "fire tubes" running through the kettle wall. The heating elements are controlled by a thermostat. The kettle holds enough oil so that the food is supported by displacement of the oil, rather than by the bottom of the vessel. There are three primary types of fryers: open deep-fat fryers, pressure fryers , and specialty fryers. Open fryers are the most common. [4]

During food service operations the fryers are turned on at the beginning of the day and turned off at the end of the shift; the fryer cycles on and off to maintain the desired temperature setting. Fryers are estimated to be idle 75% of the time. [4]

ENERGY STAR fryers are up to 30% more efficient than non-ENERGY STAR rated fryers. [5]

APPLICATION:

This measure applies to ENERGY STAR qualifying open-vat fryers in commercial and institutional food processing settings. A fryer is designed to cook food in heated oil. The fryer consumes natural gas during three modes: preheat – at the beginning of the shift when the fryer is turned on and the oil is raised from room temperature to cooking temperature, idling - mainintaing the temperature of the cooking oil between cooking, and cooking – restoring heat to the oil when cold foods are dropped in the fryer.

ENERGY STAR fryers save energy by offering shorter cook times and higher production rates through advanced burner and heat exchanger designs. Fry pot insulation reduces standby losses resulting in a lower idle energy rate.

BASELINE TECHNOLOGY:

The baseline technology is a single or multiple, standard and large open-vat commercial fryer.

EFFICIENT TECHNOLOGY:

The efficient technology is a single, or multiple, open-vat fryer that is ENERGY STAR rated. Vats may be standard size (12 inches to 18 inches wide) or large size (18 to 24 inches wide)[1] [6]

Table 2. Efficient Requirements [5] [7]

Type	ENERGY STAR Requirements
ENERGY STAR Open-Vat Fryer	Single or multiple gas-fired open deep-fat fryers with cooking efficiency of >=50%, and maximum idling rates of: • Standard vat size; <=9,000 Btu/hr idling rate • Large vat fryers (larger than 18” wide);<=12,000 Btu/hr idling rate.

ENERGY IMPACTS:

The primary energy impact associated with the installation of an ENERGY STAR fryer is natural gas savings associated with a reduction in natural gas required during pre-heat, idling and cooking times. ENERGY STAR qualified fryers must meet a minimum cooking efficiency of 50%, and maximum idling rates. This savings is achieved through shorter cook times and higher production rates through advanced burner and heat

[1] The Energy Star cooking efficiency requirements are the same for standard, large, and multiple vat fryers. The idling rate requirement varies with vat size.

exchanger designs. Fry pot insulation also reduces standby losses resulting in lower idle energy rates.

NATURAL GAS SAVINGS ALGORITHM:

The energy savings algorithm is calculated by determining and comparing the annual energy usage in baseline and ENERGY STAR qualifying fryers. To determine total energy usage the calculation must determine the energy consumed during pre-heating, cooking, and idling modes.

The algorithm is based upon the methodology utilized by the Food Service Technology Center and ENERGY STAR for each vat. For both the baseline and the efficient case, the following calculation is used to determine the energy usage.

$$NG\ Usage = Days\ \times\ (Daily\ Preheat + Daily\ Idle\ + Daily\ Cooking\ )$$

where,

NG Usage	= the amount of natural gas used by the fryer annually in Btu/year
Days	= the number of days per year the fryer is in use
Daily Preheat	= the amount of natural gas used to preheat the fryer daily in Btu/day
Daily Idle	= the amount of natural gas used when the fryer is in idle mode in Btu/day
Daily Cooking	= the amount of natural gas used when the fryer is cooking in Btu/day

The daily idle energy is calculated using the following equation:

$$Daily\ Idle = Idle\ Time \times Idle\ Rate$$

where,

Idle Time	= length of time the unit is idle per day in hours
Idle Rate	= energy consumed during idling in Btu/hr

The idle time is calculated using the following equation:

$$Idle\ Time = Total\ Operating\ Hours - Preheat\ Time - Cooking\ Time$$

where,

Idle Time	= length of time the unit is idle per day in hours
Total Operating Hours	=amount of time fryers operate a day in hours
Preheat Time	= length of time unit is in preheat mode in hours
Cooking Time	=amount of time fryers are cooking food in hours

$$Daily\ Cooking = \frac{Food\ Weight \times ASTM\ Energy\ to\ Food\ Rate}{Efficiency}$$

where,

Food Weight	= average quantity of food cooked in unit per day in pounds
ASTM Energy to Food Rate	= rate at which energy is transferred to food in Btu/lb
Efficiency	= efficiency of the unit

The savings is then calculated from the difference between the baseline and efficient cases.

$$NG_{savings} = (NG\ Usage_{baseline} - NG\ Usage_{ENERGY\ STAR}) \times \frac{1\ m^3}{35{,}738\ Btu}$$

where,

$NG_{savings}$	= annual reduction in natural gas consumption in m^3/year
$NG\ Usage_{baseline}$	= annual energy usage of a conventional fryer in Btu/year
$NG\ Usage_{ENERGY\ STAR}$	= annual energy usage for an ENERGY STAR fryer in Btu/year

List of Assumptions

The assumptions used to calculate natural gas savings are shown in Table 3.

Table 3. Assumptions List

Parameter	Baseline	High Efficiency	Source
Days	312		Common assumptions table
Preheat Time (hours)	0.175		[1]
Preheat Energy (Btu)	18,500	16,000	[1]
Cooking Time	2		[9]
Operating hours per day	14		[1]
Idle Time (hours)	11.83		Calculated
Idle Rate (Btu/h)	17,000	9,841	[1]
Food Weight (lbs/day)	150		[1]

Parameter	Baseline	High Efficiency	Source
Heavy Load Energy to Food (Btu/pound)	577		[10] [11]
Efficiency	35%	50%	[1], [7]
Conversion	35,738 Btu/m^3		Common assumptions table

Savings Calculation Example

The example below illustrates how the deemed savings value is determined for an ENERGY STAR Fryer with typical hours of usage.

Annual Conventional Fryer Usage:

$$Daily\ Preheat = 18{,}500\ Btu$$

$$Daily\ Idle = 11.825\ hours\ \times\ 17{,}000\frac{Btu}{hr} = 201{,}025\ Btu$$

$$Daily\ Cooking = \frac{150\ pounds\ \times\ 577\ Btu/pound}{35\%} = 247{,}286\ Btu$$

To calculate the annual conventional fryer consumption:

$$NG\ Usage = 312\frac{days}{year} \times \left(18{,}500\frac{Btu}{day} + 201{,}025\frac{Btu}{day} + 247{,}286\frac{Btu}{day}\right) = 145{,}644{,}943\frac{Btu}{year}$$

Annual ENERGY STAR Fryer Usage:

$$Daily\ Preheat = 16{,}000\ Btu$$

$$Daily\ Idle = 11.83\ hours\ \times\ 9{,}841\frac{Btu}{hr} = 116{,}375\ Btu$$

$$Daily\ Cooking = \frac{150\ pounds\ \times\ 577\ Btu/pound}{50\%} = 173{,}100\ Btu$$

To calculate the annual ENERGY STAR fryer consumption:

$$NG\ Usage = 312\frac{days}{year} \times \left(16{,}000\frac{Btu}{day} + 116{,}375\frac{Btu}{day} + 173{,}100\frac{Btu}{day}\right) = 95{,}308{,}295\frac{Btu}{year}$$

Natural Gas Savings:

$$NG_{savings} = (145{,}644{,}943\ Btu - 95{,}308{,}295\ Btu) \times \frac{1}{35{,}738\ \frac{Btu}{m^3}} = 1{,}408\ m^3$$

Uses and Exclusions

To qualify for this measure the fryer must be utilized for food preparation or processing with natural gas as its energy source and be ENERGY STAR rated.

MEASURE LIFE

The measure life attributed to this measure is 12 years. [1]

INCREMENTAL COST

Table 4 presents the measure incremental cost.

Table 4. Measure Incremental Cost [2] [3]

Measure Category	Incremental Cost ($)
New Construction or Time of Natural Replacement	$3,405

REFERENCES

[1] Food Service Technology Center, "Gas Fryer Life-Cycle Cost Calculator," Fisher-Nickel, Inc., 2014. [Online]. Available: http://www.fishnick.com/saveenergy/tools/calculators/gfryercalc.php. [Accessed July 2014].

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COMMERCIAL ENERGY STAR CONVECTION OVEN- NEW CONSTRUCTION AND TIME OF NATURAL REPLACEMENT

DATE: 12/03/2014

TO: Ontario TEC Committee

FROM: ERS

RE: ENERGY STAR Convection Oven - Full Size

The following TRM measure covers ENERGY STAR Convection Ovens for commercial kitchens. We have reviewed the documentation provided to us by the TEC, the current documentation available from the Food Service Technology Center, as well as other TRMs which include gas cooking measures. We also researched both Canadian and U.S. ENERGY STAR documents and were able to utilize descriptive guidance that is published by the program

Based upon our research we have adopted the methodology and baseline currently utilized by the Food Service Technology Center.

This document results from the review of the documentation and provides a single TRM section addressing ENERGY STAR convection ovens.

COMMERCIAL ENERGY STAR CONVECTION OVEN - NEW CONSTRUCTION AND TIME OF NATURAL REPLACEMENT - FULL SIZE

Version Date and Revision History	
Draft Date:	12/03/2014
Effective Date:	TBD
End Date:	TBD
Commercial →ENERGY STAR Convection Oven – Full Size →New Construction/Time of Natural Replacement → Food Service	

Table 1 provides a summary of the key measure parameters.

Table 1. Measure Key Data

Parameter	Definitions
Measure Category	New Construction (NC) Time of Natural Replacement (TNR)
Base Technology	A conventional, full-size convection oven
Efficient Technology	A full-size ENERGY STAR rated convection oven
Market type	All commercial and institutional buildings providing food Service
Annual Natural Gas Savings	865 m^3
Measure Life	12 years
Incremental Cost	$875

OVERVIEW

Convection ovens are used in commercial and institutional food service preparation as an alternative to conventional ovens. As food cooks in a conventional oven, it is surrounded by a layer of cooler air due to the lower temperature of the food item(s) being cooked. Convection ovens differ from conventional ovens in that a motorized fan (or blower) pulls in air from the oven cavity, heats it, and distributes it back into the oven cavity, resulting in a faster and more even cooking process. Convection ovens are thermostatically controlled appliances. The oven is left on during operations and cycles on and off to maintain the desired temperature setting. [4] This measure focuses on full size commercial convection ovens. Convection ovens consume natural gas when they are pre-heating, idling and cooking. "Standard gas convection ovens have a 30% cooking energy efficiency and an idle energy rate of 19,000 Btu/h, whereas ENERGY STAR certified gas convection ovens must meet the specification requirements of 46% cooking energy efficiency and idle energy rate of 12,000 Btu/h." [1]

APPLICATION

This measure applies to the installation of a full size ENERGY STAR qualifying convection oven in commercial and industrial food processing settings. Convection ovens are designed to cook food within a heated enclosed space, with the food being manually placed into the oven and removed when the cooking process is complete.

BASELINE TECHNOLOGY

The baseline technology is a full size convection oven that is not ENERGY STAR rated.

EFFICIENT TECHNOLOGY

The efficient technology is a full size convection oven that is ENERGY STAR rated. Table 2 shows the requirements for this measure.

Table 2. Efficient Requirements [1]

Type	ENERGY STAR Requirements
ENERGY STAR Convection Oven – Full Size	Idle rate ≤ 12,000 Btu/hr and cooking energy efficiency of ≥ 46%

ENERGY IMPACTS

The primary energy impact associated with the installation of a full-size ENERGY STAR convection oven is a reduction in natural gas required during pre-heating, idling and cooking. ENERGY STAR qualified gas convection ovens must meet the specification requirements of 46% cooking energy efficiency and idle energy rate of 12,000 Btu/h. The savings are achieved through reduced cooking time and lower idle energy rate.

NATURAL GAS SAVINGS ALGORITHM

The energy savings algorithm compares the annual energy usage of the standard convection equipment and ENERGY STAR qualifying convection ovens. To determine total energy usage, the calculation must determine the energy consumed in the pre-heating, cooking, and idling modes.

The algorithm is based upon the methodology utilized by the Food Service Technology Center. The calculation to determine the energy usage of baseline and ENERGY STAR ovens is as follows:

$$NG\ Usage = Days\ \times\ (Daily\ Preheat + Daily\ Idle\ + Daily\ Cooking\ )$$

where,

NG Usage	= the amount of natural gas used by the oven annually in Btu/year
Days	= the number of days per year the oven is in use
Daily Preheat	= the amount of natural gas used to preheat the oven daily in Btu/day
Daily Idle	= the amount of natural gas used when the oven is in idle mode in Btu/day
Daily Cooking	= the amount of natural gas used when the oven is cooking in Btu/day

The *"Daily Idle"* usage is calculated by the following equation:

$$Daily\ Idle = Idle\ Time \times Idle\ Rate$$

where,

Idle Time	= length of time the unit is idle per day in hours.
Idle Rate	= energy consumed during idling in Btu/hr

The idle time is calculated by subtracting the preheat time and the times the ovens are in heavy load cooking mode from the number of hours the equipment is on per day. This is shown in the following expression:

$$Idle\ Time = Total\ Operating\ Hours - Preheat\ Time - Daily\ Cooking\ Time$$

where,

Total Operating Hours	= length of time in hours where unit is turned on
Preheat Time	= length of time in hours when unit is in preheat mode
Daily Cooking Time	= length of time in hours where unit is cooking

The daily cooking time is calculated with the following equation:

$$Daily\ Cooking\ Time = \frac{Food\ Weight}{Production\ Capacity}$$

where,

Food Weight	= average quantity of food cooked in unit per day in lbs/day
Production capacity	= the maximum production rate of the appliance while cooking in accordance with the heavy-load cooking test in lbs/hr

Finally, the daily energy consumed during cooking is calculated as follows:

$$Daily\ Cooking\ Time = \frac{Food\ Weight \times ASTM\ Energy\ to\ Food\ Rate}{Efficiency}$$

where,

Food Weight = average quantity of food cooked in unit per day in lbs

ASTM Energy to Food Rate = rate at which energy is transferred to food in Btu/lb

Efficiency = efficiency of the unit

The savings is then calculated from the difference between the baseline and efficient cases.

$$NG_{savings} = (NG\ Usage_{baseline} - NG\ Usage_{ENERGY\ STAR}) \times \frac{1m^3}{35{,}738\ Btu}$$

where,

$NG_{savings}$ = annual reduction in natural gas consumption in m^3/year

$NG\ Usage_{baseline}$ = annual energy usage of a conventional oven in Btu/year

$NG\ Usage_{ENERGY\ STAR}$ = annual energy usage for an ENERGY STAR oven in Btu/year

LIST OF ASSUMPTIONS

The assumptions used to calculate natural gas savings are shown in Table 3.

Table 3. Assumptions List

Parameter	Baseline	High Efficiency	Source
Days	312		Common assumptions table
Preheat Time (hrs)	0.20		[5]
Total Operating Hours (hrs)	12		[3]
Preheat Energy (Btu/day)	19,000	11,000	[2]
Idle Time (hrs/day)	10.4	10.6	Calculated
Idle Rate (Btu/hr)	18,000	11,758	[2]
Food Weight (lbs/day)	100		[2]
ASTM Energy to Food Rate (Btu/lb)	250		[2], [6], [7]
Production Capacity (lbs/hr)	70	83	[2]

Parameter	Baseline	High Efficiency	Source
Efficiency	30%	46%	[1]
Natural gas conversion	35,738 Btu/m^3		Common assumptions table

SAVINGS CALCULATION EXAMPLE

The example below illustrates how the deemed savings value is determined for an ENERGY STAR convection oven – full size with typical hours of usage.

Daily Conventional Convection Oven Usage:

$$Daily\ Preheat = 19{,}000\,\frac{Btu}{day}$$

$$Daily\ Cooking\ Time = \frac{100\,\frac{lbs}{day}}{70\,\frac{lbs}{hr}} = 1.43\,\frac{hrs}{day}$$

$$Idle\ Time = 12\,\frac{hrs}{day} - 0.2\,\frac{hrs}{day} - 1.43\,\frac{hrs}{day} = 10.4\,\frac{hrs}{day}$$

$$Daily\ Idle = 10.4\,\frac{hrs}{day} \times 18{,}000\,\frac{Btu}{hr} = 186{,}686\,\frac{Btu}{day}$$

$$Daily\ Cooking = \frac{100\,\frac{lbs}{day} \times 250\,\frac{Btu}{lb}}{30\%} = 83{,}333\,\frac{Btu}{day}$$

$$NG\ Usage = \left(19{,}000\,\frac{Btu}{day} + 186{,}686\,\frac{Btu}{day} + 83{,}333\,\frac{Btu}{day}\right) \times 312\,\frac{days}{year} = 90{,}173{,}943\,\frac{Btu}{year}$$

Daily ENERGY STAR Convection Oven Usage:

$$Daily\ Preheat = 11{,}000\ Bt$$

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Gas Convection Oven Life-Cycle Cost Calculator
About | How To Use | Definitions

User Inputs			
Choose an Oven: (optional) -- Brand -- -- Model --	User Input Oven	Base Efficiency Oven	Energy Efficient Oven
User Inputs			
Oven Performance *(Based on ASTM Standard Test Method F1496)*			
Oven Size (Select from Box at Right)	Full Size	Full Size	Full Size
Preheat Energy (Btu)		19000	11000
Idle Energy Rate (Btu/h)		18000	11758
Heavy-Load Energy Efficiency (%)		30.0	45.0
Production Capacity (lbs/h)		70.0	83.0
Oven Usage			
Operating Hours per Day (h/day)	12.0	12.0	12.0
Operating Days per Year (d/year)	365	365	365
Number of Preheats per Day (#/day)	1	1	1
Pounds of Food Cooked per Day (lbs/day)	100.0	100.0	100.0
Utility Cost and Lifespan			
Choose State (Optional)	CA	CA	CA
Gas Cost per Therm ($/therm)	0.916	0.916	0.916
Lifespan of Oven in Years (years)	12.0	12.0	12.0
Discount Rate (%/year)	0.00	0.00	0.00
	Calculate!	Reset Fields	
Annual Results			

$$Daily\ Cooking\ Time = \frac{100\,\frac{lbs}{day}}{83\,\frac{lbs}{hr}} = 1.20\,\frac{hrs}{day}$$

$$Idle\ Time = 12\,\frac{hrs}{day} - 0.2\,\frac{hrs}{day} - 1.20\,\frac{hrs}{day} = 10.6\,\frac{hrs}{day}$$

$$Daily\ Idle = 10.6\,\frac{hrs}{day} \times 11{,}758\,\frac{Btu}{hr} = 124{,}578\,\frac{Btu}{day}$$

$$Daily\ Cooking = \frac{100\,\frac{lbs}{day} \times 250\,\frac{Btu}{lb}}{46\%} = 54{,}348\,\frac{Btu}{day}$$

$$NG\ Usage = \left(11{,}000\,\frac{Btu}{day} + 124{,}578\,\frac{Btu}{day} + 54{,}348\,\frac{Btu}{day}\right) \times 312\,\frac{days}{year} = 59{,}256{,}900\,\frac{Btu}{year}$$

$Natural\ Gas\ Savings$:

$$NG_{savings} = (90{,}173{,}943 - 59{,}256{,}900) \times \frac{1\ Btu}{35{,}738\ m^3} = 865\,\frac{m^3}{year}$$

Uses and Exclusions

To qualify for this measure the full size convection oven must be utilized for food preparation or processing with natural gas as its energy source and must be ENERGY STAR rated.

MEASURE LIFE

The measure life attributed to this measure is 12 years. [2]

INCREMENTAL COST

Table 4 presents the measure incremental cost.

Table 4. Measure Incremental Cost [3] [8]

Measure Category	Incremental Cost ($)
New Construction/Time of Natural Replacement	$875

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Commercial ENERGY STAR Steam Cookers- New Construction and Time of Natural Replacement

DATE: 12/03/2014

TO: Ontario TEC Committee

FROM: ERS

RE: ENERGY STAR Steam Cookers

The following TRM measure covers ENERGY STAR steam cookers for commercial kitchens. We have reviewed measure documentation from the following sources:

- Existing measure documentation provided to us by the TEC
- ENERGY STAR; U.S. and Canada – Specifications, Fact Sheets, and Case Studies
- Food Service Technology Center
- Other TRMs which include gas cooking measures

Based upon our research have adopted the methodology and baseline presently utilized by the Food Service Technology Center.

The measure savings are based on six-pan steam cookers as they account for the majority of products (9 out of 14) listed on the ENERGY STAR approved products lists.

ENERGY STAR STEAM COOKER

Version Date and Revision History	
Draft Date:	12/03/2014
Effective Date:	TBD
End Date:	TBD
Commercial →ENERGY STAR Steam Cookers→New Construction/Time of Natural Replacement→ Food Service	

Table 1 provides a summary of the key measure parameters.

Table 1. Measure Key Data

Parameter	Definitions
Measure Category	New Construction (NC) Time of Natural Replacement (TNR)
Base Technology	Boiler-Based Steam Cooker
Efficient Technology	ENERGY STAR Rated Steam Cooker
Market type	Food Service
Annual Natural Gas Savings	8,889 m^3
Water Savings	340,142 liters (89,856 gallons)
Measure Life	12 years
Incremental Cost	$1,035
Uses and Exclusions	Measure is limited to steam cookers that have either a connectionless or steam-generator design.

OVERVIEW

Steam cookers are used in commercial and institutional food service preparation to cook foods that do not need to form a crust. The steamer resembles an oven where food is steamed in a sealed cavity. [1]

The steam can be delivered to the cavity in several different ways. In a pressureless steamer, steam is injected through openings in the sides of the cooking compartment. A variety of foods can be cooked at the same time, and the cooking compartment door can be opened at any time during the cooking procedure. Pressure steamers use steam that has been pressurized to 5 to 15 psi. The cooking compartment needs to be depressurized before it can be opened. [2]

The steam itself may be produced in several ways:

- Boiler steamer: The steamer has an external boiler (relative to the cooking compartment) that generates potable steam.
  - Pressurized steamers: The pressurized steam is delivered as demanded by control settings. Compartment must be depressurized before it is opened.
  - Pressureless steamer: The compartment is openly connected to a condensate drain and the pressure in the compartment is at or slightly above atmospheric pressure.
- Steam generator: The steam generator is located within or connected to the cooking cavity, generating steam at (or slightly above) atmospheric pressure.
- "Connectionless" Steamer: the steam is produced by boiling water delivered directly to a reservoir located within the cooking compartment prior to operation. [1]

There are several steam cooker configurations which include: countertop models, wall-mounted models, and floor models mounted on pedestal or cabinet-style base. Commercial steamers come in different sizes, but steamers holding six or more pans are the most common, based on the ENERGY STAR approved products list. [3] 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. [4]

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. [1]

APPLICATION

This measure applies to the installation of ENERGY STAR qualifying steam cookers in commercial and institutional food preparation. The food is manually placed into the steamer and removed when the cooking is complete. Steam cookers consume natural gas when they are pre-heating, idling and cooking.

BASELINE TECHNOLOGY

The baseline technology is a standard boiler-based steam cooker. No boiler-based steam cookers are ENERGY STAR-listed as their efficiency levels fall below the ENERGY STAR requirements. Boiler-based steamers are connected to a potable water line and continually supply steam to the cooking compartment, leading to high idle energy consumption [1]

EFFICIENT TECHNOLOGY

The efficient technology is an ENERGY STAR rated steam cooker meeting the criteria presented in Table 2.

Table 2. Efficient Requirements [5]

Type	ENERGY STAR Requirements
6-pan ENERGY STAR Steam Cooker	ENERGY STAR rated Steam Cooker used in a commercial or institutional environment, with a minimum efficiency of 38% and a maximum idle-rate of 12,500 Btu/hr

The majority of ENERGY STAR steamers on the qualifying products list are "connectionless." "Connectionless steamers" do not require potable water feed, or condensate drain connections. Water is poured into a compartment at the bottom that is refilled during the day and any remaining water at the end of operation is drained from the cavity into a pan or bucket. [1] ENERGY STAR steam generation cookers require a water connection and a condensate drain, but offers improved efficiency over standard boiler-based cookers.

ENERGY IMPACTS

The primary energy impact associated with the installation of an ENERGY STAR steam cooker is a reduction in natural gas required during pre-heat, idle and cooking modes.

Connectionless steamers are inherently more energy efficient than boiler-based or conventional steam generation systems since any steam that does not condense on the food remains in the cooking compartment, rather than being condensed and drained. [1]

ENERGY STAR qualified steam cookers must meet the specification requirements of 38% natural gas minimum cooking efficiency, and a maximum idle rate. The idle rate requirement varies with the size of the steamer. The savings are achieved through shorter cook times, higher production rates, through improved steam delivery, and reduced heat loss due to better insulation. Water savings are also achieved through reduced consumption of steam during shorter cooking times and reduced condensate draining. [4] [6]

NATURAL GAS SAVINGS ALGORITHM

The energy savings algorithm is calculated by determining and comparing the annual energy usage in baseline and ENERGY STAR steam cookers. To determine total energy usage, the calculation must determine the energy consumed during pre-heating, cooking, and idling modes.

The algorithm is based upon the methodology utilized by the Food Service Technology Center and ENERGY STAR. For both the baseline and the efficient case, the following calculation is used to determine the energy usage.

$$NG\ Usage = Days\ \times\ (Daily\ Preheat + Daily\ Idle\ + Daily\ Cooking\ )$$

where,

NG Usage = the amount of natural gas used by the steam cooker annually in Btu/year

Days = the number of days per year the steam cooker is in use

Daily Preheat = the amount of natural gas used to preheat the steam cooker daily in Btu/day

Daily Idle = the amount of natural gas used daily when the steam cooker is in idle mode in Btu/day

Daily Cooking = the amount of natural gas used daily when the steam cooker is cooking in Btu/day

The *"Daily Idle"* energy is calculated using the following equation:

$$Daily\ Idle = Actual\ Idling + Residual\ Idling$$

where,

Actual Idling = energy consumed when unit is actually idling in Btu/day

Residual Idling = energy consumed in manual mode during idling in Btu/day

The baseline steamers operate in manual mode 90% of the time. That means that the operator has control of the unit, and the steamer will typically be maintained at a constant steam mode, using energy equivalent to when cooking. During that time, "idle" energy rate is equal to full-load energy rate. ENERGY STAR units are typically controlled by an integral timer.

The "*Actual Idling*" energy is calculated using the following equation:

$$Actual\ Idling = (1 - \%Manual\ Mode) \times Idle\ Rate \times Idling\ Time$$

where,

%Manual Mode =Percentage of time unit is injecting steam in the cavity but is not actually cooking

Idle Rate = Idling energy rate in Btu/hr

Idling Time = Time unit is in idle mode in hours

The "*Idling Time*" is determined using the following equation:

$$Idling\ Time = Total\ Hours\ of\ Operation - Preheat\ time - \frac{Food\ Cooked\ per\ Day}{Production\ Capacity}$$

where,

Total Hours of Operation = Total hours unit is operation in hours

Preheat time = time it takes to preheat the unit to operating temperature in hours

Food cooked per day = amount of food cooked by unit per day in lbs/day

Production capacity = the average load capacity of unit to cook food in lbs/hr.

The expression "$\frac{Food\ Cooked\ per\ Day}{Production\ Capacity}$" calculates the actual cooking time.

The other portion of the *Daily Idling* use is the *Residual Idling*. This is the amount of energy the unit is on manual mode and continually providing steam without the need for cooking. The expression to calculate this is as follows:

$$Residual\ Idling = \%Manual\ Mode \times \frac{Production\ Capacity \times ASTM\ Energy\ to\ Food\ Rate}{Efficiency} \times\ Idling\ Time$$

where,

ASTM Energy to Food Rate = rate at which energy is transferred to food in Btu/lb

Efficiency = efficiency of the unit

The expression, "$\frac{Production\ Capacity \times ASTM\ Energy\ to\ Food\ Rate}{Efficiency}$," in the "*Residual Idling*" equation calculates the cooking rate in Btu/hr. During manual mode, the unit will provide steam at the cooking rate.

The daily cooking energy is calculated as follows:

$$Daily\ Cooking = \frac{Food\ Cooked\ per\ Day \times ASTM\ Energy\ to\ Food\ Rate}{Efficiency}$$

where,

Daily Cooking= the amount of natural gas used when the unit is cooking in Btu/day. The savings is then calculated from the difference between the baseline and efficient cases.

$$NG_{savings} = (NG\ Usage_{baseline} - NG\ Usage_{ENERGY\ STAR}) \times \frac{1m^3}{35{,}738Btu}$$

where,

$NG_{savings}$ = annual reduction in natural gas consumption in m³/year

$NG\ Usage_{baseline}$ = annual energy usage of a conventional steamer in Btu/year

$NG\ Usage_{ENERGY\ STAR}$ = annual energy usage for an ENERGY STAR steamer in Btu/year

WATER SAVINGS ALGORITHM

There are also water savings associated with this measure. They are calculated according to this formula:

$$Water\ Saved = Days \times Total\ Hours\ of\ Operation \times (Water\ Use_{baseline} - Water\ Use_{ENERGY\ STAR})$$

where,

Total Hours of Operation = the total hours unit is operating per day

Water Use = the water use of the unit in liters per hour

LIST OF ASSUMPTIONS

The assumptions used to calculate natural gas savings are shown in Table 3.

Table 3. Assumptions List

Parameter	Baseline	High Efficiency	Source
Days	312		Common assumptions table
Operation Time (hours)	12		[7] [8]
Preheat Time (hours)	0.17		[9]
Preheat Energy (Btu/h)	20,000	9,000	[7]
Idle Rate (Btu/hr)	15,000	2,921	[7]
Production Capacity (lbs/hr)	140	125	[7]
Food Cooked per Day (lbs/day)	100	100	[7]
Percent of Time in Manual Mode	0.9	0	[7]
ASTM Energy to Food Rate (Btu/pound)	105		[7], [10], [11]
Efficiency	15% [7]	38% [5]	[7], [5]
Water Use(liters/hr)	136 liters/hr (36 gals/hr)	45.4 liters/hr (12 gals/hr)	[7]

SAVINGS CALCULATION EXAMPLE

The example below illustrates how the deemed savings values are determined for an ENERGY STAR Steam Cooker with typical hours of usage.

Daily Baseline Steamer Usage:

$$Daily\ Preheat = 20{,}000\,\frac{Btu}{day}$$

Daily Idle:

$$Daily\ Idle = Actual\ Idling + Residual\ Idling$$

First we need to determine actual idling time to determine actual and residual idling energy.

$$Idling\ Time = 12\ hrs - 0.17\ hrs - \frac{100\frac{lbs}{day}}{140\,\frac{lbs}{hr}} = 11.1\,\frac{hrs}{day}$$

Actual Idling:

$$Actual\ Idling = (1 - 90\%) \times 15{,}000 \frac{Btu}{hr} \times 11.1 \frac{hrs}{day} = 16{,}674 \frac{Btu}{day}$$

Residual Idling:

$$Residual\ Idling = 90\% \times \frac{140 \frac{lbs}{hr} \times 105 \frac{Btu}{lb}}{15\%} \times 11.1 \frac{hrs}{day} = 980{,}406 \frac{Btu}{day}$$

Daily Idle Energy:

$$Daily\ Idle = 16{,}674 \frac{Btu}{day} + 980{,}406 \frac{Btu}{day} = 997{,}080 \frac{Btu}{day}$$

Daily Cooking:

$$Daily\ Cooking = \frac{100 \frac{lb}{day} \times 105 \frac{Btu}{lb}}{15\%} = 70{,}000 \frac{Btu}{day}$$

Total Daily Usage:

$$NG\ Usage = \left(20{,}000 \frac{Btu}{day} + 997{,}080 \frac{Btu}{day} + 70{,}000 \frac{Btu}{day}\right) = 1{,}087{,}080 \frac{Btu}{day}$$

Total Annual Usage:

$$NG\ Usage_{Baseline} = 1{,}087{,}080 \frac{Btu}{day} \times 312 \frac{days}{year} = 339{,}168{,}826 \frac{Btu}{year}$$

Daily ENGERY STAR Usage:

$$Daily\ Preheat = 9{,}000 \frac{Btu}{day}$$

Daily Idle:

$$Daily\ Idle = Actual\ Idling + Residual\ Idling$$

First we need to determine actual idling time to determine actual and residual idling energy.

$$Idling\ Time = 12\ hrs - 0.17\ hrs - \frac{100 \frac{lbs}{day}}{125 \frac{lbs}{hr}} = 11.03 \frac{hrs}{day}$$

Actual Idling:

$$Actual\ Idling = (1 - 0\%) \times 2{,}921 \frac{Btu}{hr} \times 11.03 \frac{hrs}{day} = 32{,}219 \frac{Btu}{day}$$

Residual Idling:

$$Residual\ Idling = 0\% \times \frac{125 \frac{lbs}{hr} \times 105 \frac{Btu}{lb}}{38\%} \times 11.03 \frac{hrs}{day} = 0 \frac{Btu}{day}$$

Daily idle energy:

$$Daily\ Idle = 32{,}219\frac{Btu}{day} + 0\frac{Btu}{day} = 32{,}219\frac{Btu}{day}$$

Daily cooking:

$$Daily\ Cooking = \frac{100\frac{lb}{day} \times 105\frac{Btu}{lb}}{38\%} = 27{,}632\frac{Btu}{day}$$

Total Daily Usage:

$$NG\ Daily\ Usage = \left(9{,}000\frac{Btu}{day} + 32{,}219\frac{Btu}{day} + 27{,}632\frac{Btu}{day}\right) = 68{,}850\frac{Btu}{day}$$

Total Annual Usage:

$$NG\ Usage_{ENERGY\ STAR} = 68{,}850\frac{Btu}{day} \times 312\frac{days}{year} = 21{,}481{,}265\frac{Btu}{year}$$

Natural Gas Savings:

$$NG_{savings} = \left(339{,}168{,}826\frac{Btu}{year} - 21{,}481{,}265\frac{Btu}{year}\right) \times \frac{1}{35{,}738\frac{Btu}{m^3}} = 8{,}889\ m^3$$

Water Savings:

$$Water\ Saved = 312\frac{days}{year} \times 12\frac{hours}{day} \times \left(136.3\frac{liters}{hour} - 45.4\frac{liters}{hour}\right) = 340{,}142\frac{liters}{year}$$

USES AND EXCLUSIONS

To qualify for this measure the steam cooker must be utilized for food preparation or processing with natural gas as its energy source and be ENERGY STAR rated. The measure is limited to steam cookers that have either a connectionless or steam-generator design.

MEASURE LIFE

The measure life attributed to steam cookers is 12 years. [7]

INCREMENTAL COST

Table 4 presents the measure incremental cost. The average incremental cost for ENERGY STAR rated 6-pan, floor standing steam cookers, compared with standard efficiency steam cookers of the same type and capacity is listed.

Table 4. Measure Incremental Cost [12]

Measure Category	Incremental Cost ($)
New Construction/Time of Natural Replacement/	$1,035

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Commercial High Efficiency Underfired Broilers - New Construction and Time of Natural Replacement

DATE: 12/03/2014

TO: Ontario TEC Committee

FROM: ERS

RE: High Efficiency Under-Fired Broilers

The following TRM measure covers Under-Fired Broilers for commercial kitchens. We have reviewed the documentation provided to us by the TEC, the current documentation available from the Food Service Technology Center, as well as other TRMs which include gas cooking measures. We also researched both Canadian and U.S. Energy Star documents and were able to utilize descriptive guidance that is published by the program, but unlike many other commercial cooking measures, there are no Energy Star rated under-fired broilers, or related baseline information.

Based upon our research, we have adopted the methodology and baseline currently utilized by the Food Service Technology Center.

The measure savings are based on three-foot underfired broilers. There are additional sizes (4', 5' and 6') broilers available, and they are included in the measure documentation with savings per additional foot of broiler length.

HIGH EFFICIENCY UNDER-FIRED BROILER

Version Date and Revision History	
Draft Date:	12/03/2014
Effective Date:	TBD
End Date:	TBD
Commercial →High Efficiency Underfired Broilers →New Construction/Time of Natural Replacement→ Food Service	

Table 1 provides a summary of the key measure parameters.

Table 1. Measure Key Data

Parameter	Definitions			
Measure Category	New Construction (NC) Time of Natural Replacement (TNR)			
Base Technology	A conventional under-fired broiler, see table 2			
Efficient Technology	A high-efficiency under-fired broiler, see table 3			
Market type	Food Service (Commercial and Institutional)			
Annual Natural Gas Savings[1]	Three-foot 2,511 m^3	Four-foot 3,347 m^3	Five-foot 4,184 m^3	Six-foot 5,021 m^3
Measure Life	12 years			
Incremental Cost [1]	$1,900			

OVERVIEW:

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 come in different sizes ranging from three-foot to six-foot. High efficiency broilers utilize improved radiant design and burner control to allow lower firing and gas input levels during both preheat and cooking modes.

The basic design of an under-fired broiler is a suspended metal grill with heat applied from below. Due to their preheat times (up to 30 minutes), broilers are allowed to idle during the the day. They usually idle at full input so that they are ready to cook when they are needed. It is possible for operators to manually turn down the input, when not actively cooking, but our research revealed no automatic controls that modulate the broilers.

[1] Broiler sizes are nominal and may vary ½-foot +/- within each category.

APPLICATION:

Under-fired broilers consume natural gas when they are pre-heating and cooking. This measure provides incentives for installing a high efficiency under-fired broilers in commercial or institutional cooking settings. An under fired broiler is designed to cook food on a metal grill with the heat source below the food. The broiler is typically left on during all operating hours so that the broiler is instantly available for cooking. [1]

BASELINE TECHNOLOGY:

The baseline technology is a conventional under-fired broiler.

Table 2. Baseline Inputs [2]

Type	Inputs
Conventional under-fired broiler	Under-fired broiler, with pre-heat energy and a cooking energy rate at or below the following standard. • Three foot broiler: pre-heat of 48,000 Btu or less and a cooking energy rate of 96,000 Btu/hr or less • Four foot broiler: pre-heat between 48,0001 and 64,000 Btu and a cooking energy rate between 96,001 and 128,000 Btu/hr • Five foot broiler: pre-heat between 64,001 and 80,000 Btu and a cooking energy rate between 128,001 and 160,000 Btu/hr • Six foot broiler: pre-heat between 80,001 and 96,000 Btu and a cooking energy rate between 160,001 and 192,000 Btu/hr

EFFICIENT TECHNOLOGY:

The efficient technology is a high-efficiency under-fired broiler designed to operate at lower firing and input levels.

Table 3. Efficient Requirements [2]

Type	Requirement
High Efficiency Under-Fired broiler	Under-fired broiler, with pre-heat energy and a cooking energy rate at or below the following standard. • Three foot broiler: pre-heat of 40,500 Btu or less and a cooking energy rate of 72,000 Btu/hr or less • Four foot broiler: pre-heat between 40,501and 54,000 Btu or and a cooking energy rate between 72,001 and 96,000 Btu/hr • Five foot broiler: pre-heat between 54,001 and 67,500 Btu and a cooking energy rate between

Type	Requirement
	96,001 and 120,000 Btu/hr • Six foot broiler: pre-heat between 67,501 and 81,000 Btu and a cooking energy rate between 120,001 and 144,000 Btu/hr

ENERGY IMPACTS:

The primary energy impact associated with the installation of a high efficiency under-fired broiler is a reduction in natural gas required during the pre-heat and cook/idle modes. According to the Food Service Technology Center, broilers typically operate continuously with operators leaving the equipment at full burner output, regardless of cooking status. The energy savings is achieved through better radiant design and better burner control which allow lower gas input rates during preheating and idling/cooking activities.

NATURAL GAS SAVINGS ALGORITHM:

The algorithm to determine energy savings is calculated determining and comparing the annual energy usage for a conventional and a high efficiency under-fired broiler. To determine total energy usage, the calculation uses the energy used to pre-heat the broiler andthe energy used when cooking.

The savings algorithm is based upon the methodology developed by the Food Service Technology Center. The following calculation determines the energy usage of a conventional and high efficiency under-fired broiler:

$$NG\ Usage = Days\ \times\ (Daily\ Preheat + Full\ Burn\ Load\ \times\ Cook\ Time)$$

where,

NG Usage	= the amount of natural gas used by the broiler annually in Btu/year
Days	= the number of days per year the broiler is in use
Daily Preheat	= the amount of natural gas used to preheat the broiler daily in Btu/day
Full Burn Load	= the rate of natural gas used when the unit is in cooking mode in Btu/hr
Cook Time	= the number of hours per day that the unit is cooking

The savings is then calculated from the difference between the baseline and efficient cases.

$$NG_{savings} = \left(NG\ Usage_{baseline} - NG\ Usage_{high\ efficiency}\right) \times \frac{1m^3}{35{,}738Btu}$$

where,

$NG_{savings}$	= annual reduction in natural gas consumption in m^3/year
$NG\ Usage_{baseline}$	= annual energy usage of a conventional broiler in Btu/year
$NG\ Usage_{high\ efficiency}$	= annual energy usage for a high efficiency broiler in Btu/year

List of Assumptions

The assumptions used to calculate natural gas savings are shown in Table 4.

Table 4. Assumptions List

Parameter	Baseline	High Efficiency	Source
Days	312		Common assumptions table
Cook Time (hours)	12		[3]
Preheat time (hours)	0.33		[3]
Three foot broiler			
Daily Preheat (Btu)	48,000	40,500	[2]
Full Burn Load (Btu/hr)	96,000	72,000	[2]
Four foot broiler			
Daily Preheat (Btu)	64,000	54,000	[2]
Cooking (Btu/hr)	128,000	96,000	[2]
Five foot broiler			
Daily Preheat (Btu)	80,000	67,500	[2]
Cooking (Btu/hr)	160,000	120,000	[2]
Six foot broiler			
Daily Preheat (Btu)	96,000	81,000	[2]
Cooking (Btu/hr)	192,000	144,000	[2]

Savings Calculation Example

The example below illustrates how the deemed savings value is determined for a three foot high efficiency under-fired broiler with typical hours of usage.

Annual Conventional Broiler Usage:

$$NG\ Usage = 312\ \times \left(48{,}000\ Btu + 96{,}000\ Btuh\ \times\ (12\ hours - 0.33\ hours)\right)$$
$$= 364{,}515{,}840\ Btu$$

$Annual\ High\ Efficiency\ Broiler\ Usage$:

$$NG\ Usage = 312\ \times \left(40{,}500\ Btu + 72{,}000\ Btuh\ \times\ (12\ hours - 0.33\ hours)\right)$$
$$= 274{,}790{,}880\ Btu$$

$Natural\ Gas\ Savings$:

$$NG_{savings} = (364{,}515{,}840\ Btu - 274{,}790{,}880\ Btu) \times \frac{1}{35{,}738} = 2{,}511\ m^3$$

USES AND EXCLUSIONS

To qualify for this measure, the under-fired broiler must use natural gas as its energy source and meet the following standards:

Table 5. Assumptions List [2]

Broiler Size	Criteria
Three foot	• Preheat energy less than 40,500 Btu • Cooking energy rate less than 72,000 Btu/hr
Four foot	• Preheat energy less than 54,000 Btu • Cooking energy rate less than 96,000 Btu/hr
Five foot	• Preheat energy less than 67,500 Btu • Cooking energy rate less than 120,000 Btu/hr
Six foot	• Preheat energy less than 81,000 Btu • Cooking energy rate less than 144,000 Btu/hr

MEASURE LIFE

The measure life attributed to high efficiency under-fired broilers is 12 years. [2]

INCREMENTAL COST

Table 6 presents the measure incremental cost.

Table 6. Measure Incremental Cost [4]

Measure Category	Incremental Cost ($)
All categories of broilers	$1,900

The incremental cost is very similar for the broilers regardless of their size. This is likely due to the the burner technology being similar for high efficiency models. Cost variability between models is related to additional features.

REFERENCES

[1] Food Service Technology Center, "Commercial Cooking Appliance Technology Assesment," Fisher-Nickel, 2002, p.4-9. [Online]. Available: http://www.fishnick.com/equipment/techassessment/Appliance_Tech_Assessment.pdf. [Accessed July 2014].

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DEMAND CONTROLLED VENTILATION FOR NEW CONSTRUCTION

DATE: 4/17/2014

TO: Ontario TEC Committee

FROM: ERS

RE: Demand Controlled Ventilation – New Construction

This measure write-up is based on market research and preliminary measure development work undertaken by Enermodal Engineering on behalf of Union Gas Ltd. ERS has completed a thorough review of the final report resulting from this project, including validation of the projected savings levels for the targeted market segments. Measure substantiation sheets titled Sub Documents 1 and 2 were provided to ERS and were also reviewed and validated. Where appropriate, revisions and additions have been incorporated to reflect more recent or better-validated sources of information.

The document submitted here results from that review and provides a single TRM section addressing the demand controlled ventilation (DCV) measure for the new-construction measure categories.

Commercial → Demand Controlled Ventilation→ New Construction

DEMAND CONTROLLED VENTILATION – NEW CONSTRUCTION/TIME OF NATURAL REPLACEMENT

Version Date and Revision History	
Draft date	4/17/2014
Version history	v.1
Effective date	TBD
End date	N/A
Commercial → Demand Controlled Ventilation→ New Construction/Time of Natural Replacement	

Table 1 provides a summary of the key measure parameters, with deemed savings coefficients differentiated by facility type:

Table 1. Measure Key Data

<table>
<tr><th>Parameter</th><th colspan="2">Definitions</th></tr>
<tr><td rowspan="2">Measure category</td><td colspan="2">New Construction (NC)</td></tr>
<tr><td colspan="2">Time of Natural Replacement (TNR)</td></tr>
<tr><td>Base technology</td><td rowspan="2">New single-zone, constant volume ventilation system with natural gas fueled heating</td><td>Designed and operating in a manner that provides the minimum outdoor air requirement as specified in Table 6.2.2.1 of ASHRAE Standard 62.1-2013 [1]</td></tr>
<tr><td>Efficient technology</td><td>Ventilation rate during the occupied periods of the building schedule is modulated in response to actual CO_2 concentrations, as measured with an appropriately located CO_2 sensor</td></tr>
<tr><td>Market type</td><td colspan="2">Commercial</td></tr>
<tr><td rowspan="3">Annual natural gas savings</td><td>Space Type</td><td>Savings</td></tr>
<tr><td>Office</td><td>0.112 m^3/ft^2</td></tr>
<tr><td>Retail</td><td>0.392 m^3/ft^2</td></tr>
<tr><td>Measure life</td><td colspan="2">10 years [2]
May be extended to 15 years with documented maintenance plan (see Measure Life section)</td></tr>
<tr><td>Incremental cost</td><td colspan="2">$1050 per zone [3]</td></tr>
<tr><td>Restrictions</td><td colspan="2">Multi-zone systems, variable air volume (VAV) systems, or systems equipped with heat recovery capabilities are not eligible for this prescriptive measure.</td></tr>
</table>

OVERVIEW

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 ventilation is typically accomplished by introducing a quantity of outside air sufficient to dilute the pollutants, while the same quantity of “contaminated” air is removed from the building through either passive or active means of building exhaust.

The minimum required ventilation rate is typically established during the design process, based on applicable building codes and anticipated occupancy patterns. Consideration is also given to any special building functions expected to generate excessive levels of pollutants (various manufacturing processes, sustained high levels of human activity, etc.).

Heating, cooling, and maintaining acceptable humidity levels for the ventilation air introduced to the space represent a very significant component of the overall building energy consumption. This energy is typically much greater than the sum of all “skin losses” or surface heat transfer from the building. Excessive ventilation can be extremely costly, with little if any associated benefit.

DCV is a control strategy that automatically modulates outside air dampers to control the quantity of outside air introduced to a space based on the "demand" or level of contaminants being produced within the space. In most spaces the optimum ventilation rate fluctuates in direct proportion to occupancy and the level of activity within the space.

There can be many different types of indoor air pollutants specific to the particular building activities. One common pollutant found in all occupied spaces is CO_2, which is produced by humans through respiration. CO_2 levels expressed in parts per million (ppm) have been found to provide a good representation of overall indoor air quality, and except for cases where specific process-related pollutants overshadow their impact, have become the universally accepted controlled variable for DCV systems.

APPLICATION

This measure pertains to the implementation of DCV, based on CO_2 concentrations within the space, for single-zone, constant volume ventilation systems.

Implementation includes the installation of a CO_2 sensor in an appropriate location within the space or in the return air duct. The sensor outputs are provided to an automated control system with a programed sequence of operation that modulates the outside air damper position, controlling the ventilation rate in response to CO_2 concentrations. The controller can be part of the facility's building automation system or an independent control device, integrated within a packaged rooftop unit (RTU), air handling unit (AHU), or make-up air unit (MUA).

Installations covered under this TRM section are incorporated into new RTUs or MUAs with natural gas heating as part of new construction or overall equipment replacement projects at the time of natural replacement.

DCV can also be implemented for complex ventilation systems including multi-zone and variable air volume (VAV) systems. However, the Enermodal market research study [3] conducted prior to development of this measure correctly concluded that the relative complexity of the installations and the wide variations in achievable savings make these installations better candidates for custom incentive applications.

BASELINE TECHNOLOGY

The baseline technology is represented by an existing single-zone, constant volume ventilation system, with natural gas-fueled heating, designed and operating in a manner that provides the minimum outdoor air requirement as specified by the data provided in Table 6.2.2.1 of ASHRAE Standard 62.1-2013. [1]

These minimum design outdoor air ventilation rates are intended to meet ventilation requirements when the space is at the anticipated peak occupancy level. ASHRAE Standard 62.1, Table 6.2.2.1 provides default occupancy density values for various space types along with values representing the minimum ventilation per person and per unit of area served by the system.

The baseline system provides this minimum outdoor air requirement on a continuous basis throughout the occupied periods of the building schedule and does not provide ventilation during the unoccupied periods of the building schedule[1]. Table 2 presents the baseline requirements.

Table 2. Baseline Assumption

Type	Requirement
New single-zone, constant volume ventilation system with natural gas fueled heating	Designed and operating in a manner that provides the minimum outdoor air requirement as specified in Table 6.2.2.1 of ASHRAE Standard 62.1-2013 [1], on a continuous basis during the occupied periods

EFFICIENT TECHNOLOGY

The efficient technology is represented by the baseline ventilation system with an appropriately located CO_2 sensor, a controller, and a control algorithm established to limit the maximum outdoor air ventilation rate to that based on the ASHRAE 62.1, Table 6.2.2.1 prescribed values, equivalent to the continuous occupied period ventilation provided by the baseline system.

The CO_2 sensor measures CO_2 concentrations and provides an output signal to a stand-alone control device specific to the ventilation system. The controller will accept the input from the sensor and generate a corresponding output signal to the outside air damper actuator, adjusting the damper position as described below.

Appendix H of the Enermodal market research study [3] presents the results of a survey of RTU installers representing 1,000 DCV installations. The study confirmed that control algorithms are typically established based on an assumed differential of 700 ppm in CO_2 concentrations of ambient outside air and design condition interior air. Typical ambient air CO_2 concentrations are around 400 ppm, meaning that most systems are calibrated to allow for steady state CO_2 concentrations of up to 1,100 ppm when the space is fully occupied with the outside air dampers at the position intended to allow for the ASHRAE 62.1 prescribed design flow rate. As occupancy declines, the CO_2 concentration drops and the controller reduces the damper opening. With no occupants in the space the CO_2 concentration eventually reaches the outdoor ambient level, at which point the outside air damper is closed (or in some cases set to a minimum position as described in footnote 1 on the previous page). Table 3 presents the efficient system requirements.

Table 3. Efficient Requirements

Type	Requirement
New single-zone, constant volume ventilation system with natural gas fueled heating	Ventilation rate during the occupied periods of the building schedule is modulated in response to actual CO_2 concentrations, as measured with an appropriately located CO_2 sensor

[1] Some systems may have a fixed minimum outside air damper position, (typically 5% OA), to allow for a minimum level of ventilation even during unoccupied hours. As long as this minimum is present in both the baseline and efficient scenarios (with DCV implemented), it has no impact on the resulting measure savings.

ENERGY IMPACTS

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. Table 1 in the "Overview" section provides deemed annual savings values (m^3 natural gas / ft^2 area served), differentiated by space type. The savings are based on climate data for London, Ontario, which was selected as a proxy city for Ontario based on a weighted average analysis of Ontario's 10 largest cities, provided by Enbridge Gas. The spreadsheet analysis used population and degree data obtained from online sources and was validated as part of the review for this measure. [4] [5] [6]

Extensive analysis completed by Enermodal Engineering as part of a market research study [3] led to the conclusion that in Ontario the cooling season energy impact (electric energy savings) occurs only during a limited number of hours when the space requires cooling and outside air temperature is warmer than the space temperature. The Excel-based tool developed by Enermodal Engineering and used to derive the deemed savings values provided in Table 1 predicted cooling season electric savings equivalent to less than 1% of the projected heating natural gas savings. The predicted electric energy savings by the model is small enough to be within the level of precision that could reasonably be attained by the savings algorithm leading to the prediction.[2]

There is no water consumption impact associated with this measure.

NATURAL GAS SAVINGS ALGORITHM

As part of the Enermodal market research study [3], a spreadsheet tool was developed to predict annual natural gas savings for spaces of various types and sizes in selected locations throughout the Enbridge-Union Gas service territories. The tool is based on the algorithm described below.

The spreadsheet tool's multi-step algorithm is used to predict annual energy savings for spaces with varying end uses and sizes in five different climate zones. The results were calibrated against eQUEST-DOE-2 [7] building simulation model results for seventy–five combinations of building types, sizes, and climate zones.

The specific steps in the spreadsheet algorithm are as follows:

1. Determine the maximum anticipated occupancy and the associated design minimum outside air flow rate in cfm that is required by code [1]. This represents the baseline condition whenever the space is occupied.

$$Flow_{Design} = Occ_{Design} \times \frac{SF}{1000} \times Rp + SF \times Ra$$

where,

[2] A reduction of the system peak electrical demand could result if space occupancy during the peak period is lower than the peak occupancy levels defined by ASHRAE 62.1 table 6.2.2.1.

$Flow_{Design}$ = The design ventilation rate in expressed (cfm)

Occ_{Design} = The design occupants per 1000 square feet (from ASHRAE 62.1, Table 6.2.2.1)

SF = The area of zone served (ft^2)

Rp = The occupant ventilation rate, cfm per person (from ASHRAE 62.1, Table 6.2.2.1)

Ra = The area ventilation rate, cfm per square foot (from ASHRAE 62.1, Table 6.2.2.1)

2. Apply the appropriate occupancy schedule [8] and determine space occupancy and the associated outside air flow rate (cfm) on an hourly basis for the efficient case condition during occupied periods with DCV implemented.

$$Flow_{efficient\ case} = Occ_{Design} \times \%\,Occ \times \frac{SF}{1000} \times Rp + SF \times Ra$$

where,

$Flow_{efficient\ case}$ = The hourly efficient case ventilation rate in expressed (cfm)

$\%\,Occ$ = The value taken from US DOE commercial reference building typical occupancy schedule for the specified space type.

When the space is unoccupied the outside air flow is assumed to be zero for both the baseline and efficient case scenario.

3. Use typical hourly weather data [9] (dry-bulb temperature, humidity ratio, and outdoor air pressure) to calculate the density of air (lb/ft^3) on an hourly basis and determine the resulting mass flow rate (lb/min).

$$M = Density_{Air} \times Flow_{Hourly} \times 60\ min/hour$$

where,

M_{hourly} = The hourly mass flow rate of air (lbs/hour)

$Density_{Air}$ = The density calculated from typical weather data representing each hour in the specific climate zone (lb/ft^3)

$Flow_{Hourly}$ = The flow rate calculated in the above equations for each hour of the year (cfm)

4. Subtract the hourly outdoor air temperature from the desired supply air temperature to determine the need for heating and the temperature rise (°F) required for each hour and calculate thermal energy requirement.

$$Q = M \times Cp_{Air} \times \Delta T$$

where,

Q = The thermal energy requirement (Btu/hour)

Cp_{Air} = The specific heat of air (Btu/lb-°F)

ΔT = The difference between average hourly outdoor temperature and supply air temperature (°F)

5. Divide the hourly thermal energy requirement by the typical heating system efficiency to calculate the hourly average input energy (m³) for the baseline and efficient case conditions.

$$NG_{Hourly} = Q \,/\, Heating\ system\ efficiency$$

where,

NG_{Hourly} = The hourly natural gas consumption (m³)

$Heating\ system\ efficiency$ = The average heating system efficiency (80%) [10]

6. Sum the hour results to determine the annual energy input (kWh) of the baseline and efficient case conditions and deduct the annual efficient case energy input from the baseline value to determine the predicted annual savings in m³ of natural gas.

$$Annual\ savings = \sum_{0}^{8760} NG_{efficienct\ case} - \sum_{0}^{8760} NG_{Baseline}$$

where,

$Annual\ savings$ = The annual natural gas savings (m³/year)

$\sum_0^{8760} NG_{efficient\ case}$ = The summation of the efficient case hourly natural gas consumption

$\sum_0^{8760} NG_{Baseline}$ = The summation of the baseline hourly natural gas consumption

The results were normalized to derive the deemed annual savings per square foot of area served for the typical climate zone represented by London, Ontario, presented in Table 1.

The deemed savings values (m³ / ft²) derived from the spreadsheet tool and reflected in Table 1 are then used to calculate and report project specific savings as follows:

$$Savings_{NG} = Deemed\ savings \times Zone\ area$$

where,

$Savings_{NG}$ = The annual natural gas savings (m³)

$Deemed\ savings$ = The deemed savings value for the space type and climate zone from Table 1 (m³ / ft²)

$Zone\ area$ = The area of the zone served by the RTU, AHU, or MUA (ft²)

List of Assumptions

Table 4 provides a list of constants and assumption used in the derivation of the deemed savings values. The 80% efficiency represents a typical AFUE efficiency for natural gas-fired RTUs based on data from a number of sources, including the Natural Resources Canada website [10]. Because duct runs for single-zone RTUs are generally short and/or within the conditioned space, this value also represents a reasonable estimate of system efficiency.

Table 4. Constants and Assumptions

Parameter	Value	Units	Reference
Space temperature setpoint	72	°F	Common assumptions table
Heating system enabled	55	°F	Common assumptions table
Heating system efficiency	80%	%	Common assumptions table
Natural gas heat content	35,738	Btu/m^3	Common assumptions table

Savings Calculation Example

The example below illustrates how the deemed savings value is determined for a demand controlled ventilation installation for a 10,000 ft² office single-zone area.

$$Savings_{NG} = Deemed\ savings \times Zone\ area$$

$$= 0.112\ m^3/ft^2\ X\ 10{,}000\ ft^2$$

$$= 1{,}120\ m^3 \text{ per year}$$

Uses and Exclusions

To qualify for this measure, DCV must be implemented for a single-zone, constant volume ventilation system with natural gas-fueled heating that previously operated to provide constant ventilation meeting the minimum outdoor air requirements specified by ASHRAE 62.1, Table 6.2.2.1.

Multi zone systems, VAV systems, or systems equipped with heat recovery capabilities are not eligible for this prescriptive measure.

Measure Life

The standard measure life attributed to this measure is 10 years. [2] This measure life is based on the predicted sustained savings associated with properly calibrated sensors and a well maintained control system.

Although physical components of the ventilation system can be expected to last longer, energy savings persist only as long as sensors and other components of the DCV system remain in calibration and functioning as intended.

Self-calibrating sensors are now available. The calibration warranty period for these sensors is typically between 3 and 5 years, depending upon the manufacturer.

In specific circumstances where a documented maintenance plan is in place, measure life is extended to 15 years. The maintenance plan must provide for inspection and calibration of all control system components, including but not limited to sensors, actuators, and transducers on a regular interval of not more than 5 years.

INCREMENTAL COST

Table 5 presents the measure incremental cost.

Table 5. Measure Incremental Cost [3]

Measure Category	Cost Component	Incremental Cost ($)
New construction / time of natural replacement	Equipment	$750
	Maintenance (Year 5)	$300
	Total (10 year life)	**$1,050**
	Maintenance (Year 10)	$300
	Total (15 year life)	**$1,350**

Because the sustained savings over the measure life are dependent upon the periodic calibration of the sensors, costs associated with this effort over the anticipated 10-year measure life are included. The cost reflected above includes calibration at year 5 and in the case of a 15-year measure life at year 10, with an estimated cost of $300.

REFERENCES

[1] ASHRAE, "ANSI/ASHRAE Standard 62.1 - 2013, Table 6.2.1.1, Page 12-16," American Society of Heating, Refrigeration and Air-Conditioning Engineers, Atlanta, 2013.

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DEMAND CONTROLLED VENTILATION FOR RETROFIT

DATE: 4/17/2014

TO: Ontario TEC Committee

FROM: ERS

RE: Demand Controlled Ventilation – Retrofit

This measure write-up is based on market research and preliminary measure development work undertaken by Enermodal Engineering on behalf of Union Gas Ltd. ERS has completed a thorough review of the final report resulting from this project, including validation of the projected savings levels for the targeted market segments. Measure substantiation sheets entitled Sub Documents 1 and 2 were provided to ERS and were also reviewed and validated. Where appropriate, revisions and additions have been incorporated to reflect more recent or better-validated sources of information.

The document submitted here results from that review and provides a single TRM section addressing the demand controlled ventilation (DCV) measure for the retrofit measure categories.

Commercial → Demand Controlled Ventilation→ Retrofit

DEMAND CONTROLLED VENTILATION – RETROFIT

Version Date and Revision History	
Draft date	4/17/2014
Version history	v.1
Effective date	TBD
End date	N/A
Commercial → Demand Controlled Ventilation→ Retrofit	

Table 1 provides a summary of the key measure parameters, with deemed savings coefficients differentiated by facility type.

Table 1. Measure Key Data

Parameter	Definitions	
Measure category	Retrofit (R)	
Base technology	Existing single zone, constant volume ventilation system with natural gas-fueled heating	Designed and operating in a manner that provides the minimum outdoor air requirement as specified in Table 6.2.2.1 of ASHRAE Standard 62.1-2013 [1]
Efficient technology		Ventilation rate during the occupied periods of the building schedule is modulated in response to actual CO_2 concentrations, as measured with an appropriately located CO_2 sensor.
Market type	Commercial	
Annual natural gas savings	**Space Type**	**Savings**
	Office	0.112 m^3/ft^2
	Retail	0.392 m^3/ft^2
Measure life	10 years [2] May be extended to 15 years with documented maintenance plan (see Measure Life section)	
Incremental cost	$1,350 per zone [3]	
Restrictions	Multi-zone systems, VAV systems, or systems equipped with heat recovery capabilities are not eligible for this prescriptive measure.	

Overview

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 ventilation is typically accomplished by introducing a quantity of outside air sufficient to dilute the pollutants, while the same quantity of "contaminated" air is removed from the building through either passive or active means of building exhaust.

The minimum required ventilation rate is typically established during the design process, based on applicable building codes and anticipated occupancy patterns. Consideration is also given to any special building functions expected to generate excessive levels of pollutants (various manufacturing processes, sustained high levels of human activity, etc.).

Heating, cooling, and maintaining acceptable humidity levels for the ventilation air introduced to the space represent a very significant component of the overall building energy consumption. This energy is typically much greater than the sum of all "skin losses" or surface heat transfer from the building. Excessive ventilation can be extremely costly, with little if any associated benefit.

DCV is a control strategy that automatically modulates outside air dampers to control the quantity of outside air introduced to a space based on the "demand" or level of contaminants being produced within the space. In most spaces the optimum ventilation rate fluctuates in direct proportion to occupancy and the level of activity within the space.

There can be many different types of indoor air pollutants specific to the particular building activities. One common pollutant found in all occupied spaces is CO_2, which is produced by humans through respiration. CO_2 levels expressed in parts per million (ppm) have been found to provide a good representation of overall indoor air quality, and except for cases where specific process-related pollutants overshadow their impact, have become the universally accepted controlled variable for DCV systems.

APPLICATION

This measure pertains to the implementation of DCV, based on CO_2 concentrations within the space, for single-zone, constant volume ventilation systems.

Implementation includes the installation of a CO_2 sensor in an appropriate location within the space or in the return air duct. The sensor outputs are provided to an automated control system with a programed sequence of operation that modulates the outside air damper position, controlling the ventilation rate in response to CO_2 concentrations. The controller can be part of the facility's building automation system or an independent control device, integrated within a packaged roof top unit (RTU), air handling unit (AHU), or make-up air unit (MUA).

Installations covered under this TRM section are incorporated as part of a retrofit into existing functional ventilation systems.

DCV can also be implemented for complex ventilation systems, including multi-zone and variable air volume (VAV) systems. However, the Enermodal market research study [3] conducted prior to development of this measure correctly concluded that the relative complexity of the installations and the wide variations in achievable savings make these installations better candidates for custom incentive applications.

BASELINE TECHNOLOGY

The baseline technology is represented by an existing single-zone, constant volume ventilation system, with natural gas-fueled heating, designed and operating in a manner that provides the minimum outdoor air requirement as specified by the data provided in Table 6.2.2.1 of ASHRAE Standard 62.1-2013. [1]

These minimum-design outdoor air ventilation rates are intended to meet ventilation requirements when the space is at the anticipated peak occupancy level. ASHRAE Standard 62.1, Table 6.2.2.1 provides default occupancy density values for various space types along with values representing the minimum ventilation per person and per unit of area served by the system.

The baseline system provides this minimum outdoor air requirement on a continuous basis throughout the occupied periods of the building schedule, and it does not provide ventilation during the unoccupied periods of the building schedule[1]. Table 2 presents the baseline requirements.

Table 2. Baseline Assumption

Type	Requirement
Existing single-zone, constant volume ventilation system with natural gas-fueled heating	Designed and operating in a manner that provides the minimum outdoor air requirement as specified in Table 6.2.2.1 of ASHRAE Standard 62.1-2013 [1], on a continuous basis during the occupied periods

EFFICIENT TECHNOLOGY

The efficient technology is represented by the baseline ventilation system with an appropriately located CO_2 sensor, a controller, and a control algorithm established to limit the maximum outdoor air ventilation rate to that based on the ASHRAE 62.1, Table 6.2.2.1 prescribed values, equivalent to the continuous occupied period ventilation provided by the baseline system.

The CO_2 sensor measures CO_2 concentrations and provides an output signal to a stand-alone control device specific to the ventilation system. The controller will accept the input from the sensor and generate a corresponding output signal to the outside air damper actuator, adjusting the damper position as described below.

Appendix H of the Enermodal market research study [3] presents the results of a survey of RTU installers representing 1,000 DCV installations. The study confirmed that control algorithms are typically established based on an assumed differential of 700 ppm in CO_2 concentrations of ambient outside air and design condition interior air. Typical ambient air CO_2 concentrations are around 400 ppm, meaning that most systems are calibrated to allow for steady state CO_2 concentrations of up to 1,100 ppm when the space is fully occupied with the outside air dampers at the position intended to allow for the ASHRAE 62.1 prescribed design flow rate. As occupancy declines, the CO_2 concentration drops and the controller reduces the damper opening. With no occupants in the space the CO_2 concentration eventually reaches the outdoor ambient level, at which point the outside air damper is closed, (or in some cases set to a minimum position as described in footnote 1 on the previous page). Table 3 presents the efficient system requirements.

Table 3. Efficient Requirements

Type	Requirement
Existing single-zone, constant volume ventilation system with natural gas-fueled heating	Ventilation rate during the occupied periods of the building schedule is modulated in response to actual CO_2 concentrations, as measured with an appropriately located CO_2 sensor

[1]Some systems may have a fixed minimum outside air damper position, (typically 5% OA), to allow for a minimum level of ventilation even during unoccupied hours. As long as this minimum is present in both the baseline and efficient scenarios (with DCV implemented), it has no impact on the resulting measure savings.

ENERGY IMPACTS

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. Table 1 in the "Overview" section provides deemed annual savings values (m^3 natural gas / ft^2 area served), differentiated by space type. The savings are based on climate data for London, Ontario, which was selected as a proxy city for Ontario based on a weighted average analysis of Ontario's 10 largest cities, provided by Enbridge Gas. The spreadsheet analysis used population and degree data obtained from online sources and was validated as part of the review for this measure. [4] [5] [6]

Extensive analysis completed by Enermodal Engineering as part of a market research study [3] led to the conclusion that in Ontario the cooling season energy impact (electric energy savings) occurs only during a limited number of hours when the space requires cooling and outdoor air temperature is warmer than the space temperature. The Excel-based tool developed by Enermodal Engineering and used to derive the deemed savings values provided in Table 1 predicted cooling season electric savings equivalent to less than 1% of the projected heating natural gas savings. The predicted electric energy savings by the model is small enough to be within the level of precision that could reasonably be attained by the savings algorithm leading to the prediction.[2]

There is no water consumption impact associated with this measure.

NATURAL GAS SAVINGS ALGORITHM

As part of the Enermodal market research study [3], a spreadsheet tool was developed to predict annual natural gas savings for spaces of various types and sizes in selected locations throughout the Enbridge-Union Gas service territories. The tool is based on the algorithm described below.

The spreadsheet tool's multi-step algorithm is used to predict annual energy savings for spaces with varying end uses and sizes in five different climate zones. The results were calibrated against eQUEST-DOE-2 [7] building simulation model results for seventy-five combinations of building types, sizes, and climate zones.

The specific steps in the spreadsheet algorithm are as follows:

1. Determine the maximum anticipated occupancy and the associated design minimum outside air flow rate in cfm that is required by code [1]. This represents the baseline condition whenever the space is occupied.

$$Flow_{Design} = Occ_{Design} \times \frac{SF}{1000} \times Rp + SF \times Ra$$

where,

[2] A reduction of the system peak electrical demand could result if space occupancy during the peak period is lower than the peak occupancy levels defined by ASHRAE 62.1 table 6.2.2.1.

$Flow_{Design}$ = The design ventilation rate in expressed (cfm)

Occ_{Design} = The design occupants per 1000 square feet (from ASHRAE 62.1, Table 6.2.2.1)

SF = The area of zone served (ft^2)

Rp = The occupant ventilation rate, cfm per person (from ASHRAE 62.1, Table 6.2.2.1)

Ra = The area ventilation rate, cfm per square foot (from ASHRAE 62.1, Table 6.2.2.1)

2. Apply the appropriate occupancy schedule [8] and determine space occupancy and the associated outside air flow rate (cfm) on an hourly basis for the efficient case condition during occupied periods with DCV implemented.

$$Flow_{efficienct\ case} = Occ_{Design} \times \%\ Occ \times \frac{SF}{1000} \times Rp + SF \times Ra$$

where,

$Flow_{efficient\ caset}$ = The hourly efficient case ventilation rate in expressed (cfm)

$\%\ Occ$ = The value taken from US DOE commercial reference building typical occupancy schedule for the specified space type

When the space is unoccupied the outside air flow is assumed to be zero for both the baseline and efficient case scenario.

3. Use typical hourly weather data [9] (dry-bulb temperature, humidity ratio, and outdoor air pressure) to calculate the density of air (lb/ft^3) on an hourly basis and determine the resulting mass flow rate (lb/min).

$$M = Density_{Air} \times Flow_{Hourly} \times 60\ min/hour$$

where,

M_{Hourly} = The hourly mass flow rate of air (lbs/hour)

$Density_{Air}$ = The density calculated from typical weather data representing each hour in the specific climate zone (lb/ft^3)

$Flow_{Hourly}$ = The flow rate calculated in the above equations for each hour of the year (cfm)

4. Subtract the hourly outdoor air temperature from the desired supply air temperature to determine the need for heating and the temperature rise (°F) required for each hour and calculate the thermal energy requirement.

$$Q = M \times Cp_{Air} \times \Delta T$$

where,

Q = The thermal energy requirement (Btu/hour)

Cp_{Air} = The specific heat of air (Btu/lb-°F)

ΔT = The difference between average hourly outdoor temperature and supply air temperature (°F)

5. Divide the hourly thermal energy requirement by the typical heating system efficiency to calculate the hourly average input energy (m^3) for the baseline and efficient case conditions.

$$NG_{Hourly} = Q \;/\; Heating\ system\ efficiency$$

where,

NG_{Hourly} = The hourly natural gas consumption (m^3)

$Heating\ system\ efficiency$ = The average heating system efficiency (80%) [10]

6. Sum the hour results to determine the annual energy input (kWh) of the baseline and efficient case conditions and deduct the annual efficient case energy input from the baseline value to determine the predicted annual savings in m^3 of natural gas.

$$Annual\ savings = \sum_{0}^{8760} NG_{efficiennt\ case} - \sum_{0}^{8760} NG_{Baseline}$$

where,

$Annual\ savings$ = The annual natural gas savings (m^3/year)

$\sum_0^{8760} NG_{efficient\ case}$ = The summation of the efficient case hourly natural gas consumption

$\sum_0^{8760} NG_{Baseline}$ = The summation of the baseline hourly natural gas consumption

The results were normalized to derive the deemed annual savings per square foot of area served for the typical climate zone represented by London, Ontario presented in Table 1.

The deemed savings values (m^3 / ft^2) derived from the spreadsheet tool and reflected in Table 1 are then used to calculate and report project specific savings as follows:

$$Savings_{NG} = Deemed\ savings \times\ Zone\ area$$

where,

$Savings_{NG}$ = The annual natural gas savings (m^3)

$Deemed\ savings$ = The deemed savings value for the space type and climate zone from Table 1 (m^3 / ft^2)

$Zone\ area$ = The area of the zone served by the RTU, AHU, or MUA (ft^2)

LIST OF ASSUMPTIONS

Table 4 provides a list of constants and assumption used in the derivation of the deemed savings values. The 80% efficiency represents a typical AFUE efficiency for natural gas-fired

RTUs based on data from a number of sources including the Natural Resources Canada website [10]. Because duct runs for single-zone RTUs are generally short and/or within the conditioned space, this value also represents a reasonable estimate of system efficiency.

Table 4. Constants and Assumptions

Parameter	Value	Units	Reference
Space temperature setpoint	72	°F	Common assumptions table
Heating system enabled	55	°F	Common assumptions table
Heating system efficiency	80%	%	Common assumptions table
Natural gas heat content	35,738	Btu/m^3	Common assumptions table

SAVINGS CALCULATION EXAMPLE

The example below illustrates how the deemed savings value is determined for a DCV installation for a 10,000 ft^2 office single zone area.

$$Savings_{NG} = Deemed\ savings\ \times\ Zone\ area$$

$$= 0.112\ m^3/ft^2\ X\ 10,000\ ft^2$$

$$= 1,120\ m^3 \text{ per year}$$

USES AND EXCLUSIONS

To qualify for this measure, DCV must be implemented for a single-zone, constant volume ventilation system, with natural gas fueled heating that previously operated to provide constant ventilation meeting the minimum outdoor air requirements specified by ASHRAE 62.1 Table 6.2.2.1.

Multi-zone systems, VAV systems, or systems equipped with energy or heat recovery capabilities are not eligible for this prescriptive measure.

MEASURE LIFE

The standard measure life attributed to this measure is 10 years. [2] This measure life is based on the predicted sustained savings associated with properly calibrated sensors and a well-maintained control system.

Although physical components of the ventilation system can be expected to last longer, energy savings persist only as long as sensors and other components of the DCV system remain in calibration and functioning as intended.

Self-calibrating sensors are now available. The calibration warranty period for these sensors is typically between 3 and 5 years, depending upon the manufacturer.

In specific circumstances where a documented maintenance plan is in place, the measure life is extended to 15 years. The maintenance plan must provide for inspection and calibration of all control system components, including but not limited to sensors, actuators, and transducers on a regular interval of not more than 5 years.

INCREMENTAL COST

Table 5 presents the measure incremental cost.

Table 5. Measure Incremental Cost [3]

Measure Category	Cost Component	Incremental Cost ($)
Retrofit	Equipment	$750
	Installation	$300
	Maintenance (Year 5)	$300
	Total (10 year life)	**$1,350**
	Maintenance (Year 10)	$300
	Total (15 year life)	**$1,650**

Because the sustained savings over the measure life are dependent upon the periodic calibration of the sensors, costs associated with this effort over the anticipated 10-year measure life are included. The cost reflected above includes calibration at year 5 and in the case of a 15-year measure life at year 10, with an estimated cost of $300.

REFERENCES

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COMMERCIAL OZONE LAUNDRY TREATMENT

DATE: 6/24/2014

TO: Ontario TEC Sub-Committee

FROM: ERS

RE: Ozone Laundry Treatment

The following TRM measure covers Ozone Laundry Treatment for commercial laundry applications. We have reviewed the documentation provided to us by the TEC, including the spreadsheet analysis performed by the Natural Gas Technologies Center. We have verified the accuracy of the calculations and reasonableness of the assumptions. In addition we have researched the references provided and have investigated available sources of information. Some of the existing assumptions were supported by industry interviews conducted by the Natural Gas Technologies Center, and they are referenced as such. We have determined that the critical assumptions for this measure are not variable based on whether the treatment is added to new or existing laundry equipment.

For the incremental cost, we have used the reference provided by the Natural Gas Technologies Center. We are still in the process of verifying this cost with additional manufacturers, but have confirmed through research and manufacturer interviews that the cost is reasonable.

Commercial → Ozone Laundry→ All Measure Categories

OZONE LAUNDRY TREATMENT

Version Date and Revision History	
Draft date:	6/24/14
Effective date:	TBD
End date:	N/A
Commercial → Ozone Laundry Treatment → New Construction/Retrofit	

This document describes the ozone treatment system measure for commercial laundry facilities. Table 1 describes the key measure parameters including energy savings.

Table 1. Measure Key Data

Parameter	Definitions			
Measure category	New Construction or Retrofit			
Baseline technology	Commercial laundry with no ozone treatment system			
Efficient technology	Ozone treatment system for commercial laundry			
Market type	Commercial			
Annual Energy Savings [1]	**Washer Type**	**Natural Gas Savings Factor - NGSF (m^3/(lb-yr))**	**Electric Savings - ESF (kWh/(lb-yr))**	**Water Savings - WSF (L/(lb-yr))**
	Extractor Washers	0.0367	0.00213	2.08
	Tunnel Washers	0.0293	0.00150	1.27
Measure life	15 years [2]			
Incremental cost	**Washer Type**	**Incremental Cost**		
	Washer extractor – ≤ 60 lbs	$11,000		
	Washer extractor – > 60 lbs and < 500 lbs	$25,000		
	Washer extractor – ≥ 500 lbs	$31,000		
	Tunnel washer – ≤ 120 lbs	$50,000		
	Tunnel washer – > 120 lbs and < 500 lbs	$105,000		
	Tunnel washer – ≥500 lbs	$160,000		
Restrictions	This measure is restricted to commercial clothes washers using water heated by natural gas. Washers dedicated to cleaning heavily soiled laundry are not eligible for this measure.			

OVERVIEW

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. The improved cleaning action results in hot water savings, and as a result, natural gas savings. However, since the solubility of ozone is low and its decomposition is faster at higher temperatures (38°C/100°F), the use of ozone is not recommended for heavily soiled laundry, which requires hotter water.

An important consideration with the use of ozone systems is laundry worker safety. Ozone exposure is regulated worldwide. The exposure limits for workers in Canadian facilities is limited to 0.12 parts per million over a time-weighted average of a one-hour period. The installation of an ozone system usually includes the installation of an ozone sensor to ensure that unsafe levels are not reached [3].

Error! Not a valid bookmark self-reference. shows the schematics of a laundry system equipped with an ozone treatment system.

Figure 1. Washer Extractors – Example Schematic

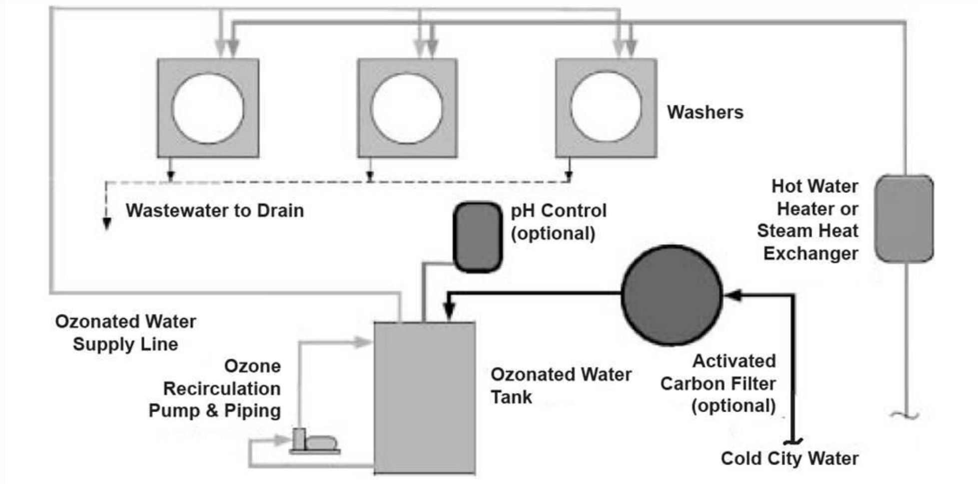

FIGURE 1. Ozone laundry systems (California Urban Water Conservation Council, 2006).

APPLICATION

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.

BASELINE TECHNOLOGY

The baseline for this measure is standard commercial laundry equipment that does not utilize ozone laundry treatment and uses natural gas for water heating.

EFFICIENT TECHNOLOGY

The efficient case for this measure is ozone laundry treatment equipment installed on commercial laundry equipment using natural gas for water heating.

ENERGY IMPACTS

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. Although the ozone system consumes additional electricity, electric savings are also realized due to the reduced cycles required per load.

NATURAL GAS SAVINGS ALGORITHMS

The quasi prescriptive savings for this measure are determined utilizing a savings calculator developed by NGTC (Natural Gas Technology Center). The factors are determined by calculating the water saved from installing an ozone generating system on a washer.

The following algorithm is used to calculate the actual gas impact in cubic meters from the natural gas savings factor.

$$\Delta(m^3) = NGSF \times WC \times Load$$

Where,

NGSF = Natural gas savings factor; see Table 1 ($m^3/(lbs/yr^2)$)

WC = Washer capacity; see **Error! Reference source not found.** (lbs/load)

Load = Annual loads processed by the washer; see application (loads/yr)

NON-GAS IMPACTS

Electrical Savings Algorithms

The following algorithm is used to calculate the electric impact in kilowatt-hours from the electric energy savings factor.

$$\Delta(kWh) = ESF \times WC \times Load$$

Where,

ESF = Electric savings factor, see **Error! Reference source not found.**1 ($kWh/(lbs/yr^2)$)

WC = Washer capacity; see application (lbs/load)

Load = Annual loads processed by the washer; see application (loads/yr)

Water Savings Algorithms

The following algorithm is used to calculate the water impact from the water savings factor.

$$\Delta(L) = WSF \times WC \times Load$$

Where,

WSF = Water savings factor; see Table 1 (L/(lbs/yr^2))

WC = Washer capacity; see application (lbs/load)

Load = Annual loads processed by the washer; see application (loads/yr)

LIST OF ASSUMPTIONS:

Table 2 shows the list of assumptions utilized in the calculations spreadsheet to derive the savings factors in Table 1. Ozone laundry systems cannot use high temperature water since ozone breaks down above 35°C [4]. It is also notable that there is broad range of water recycling capability from commercial machines depending on the rigor of the recycling purification methods. Using simple filtration, 10% to 35% of water can be recycled. By incorporating multiple filtration steps and advanced disinfecting techniques, such as ultraviolet light, up to 90% water savings can be achieved. [5]. For this analysis, operating conditions used to calculate the energy consumption per pound of laundry were evaluated using input data from representatives of an ozone laundry products manufacturer and a large linen services company. These operating conditions are assumed to be typical for industrial laundry facilities.

Table 2: List of Assumptions

Variable	Value	Sources
Supply water temperature	9.3°C	Common assumptions table
Natural gas water heater recovery efficiency	80 %	Common assumptions table
Ratio of water recycled	30.0 %[1]	[5]
Water temperature for medium soil (ozone)	20.0 °C	[2] [4]

[1] To provide a conservative estimate of gas savings, 30% water recycling was selected within the 10% - 35% range. This range is noted in [5], which for the range in turn cites “Slash Utility Consumption.” Laundry Today July/August 2005, p.12.

SAVINGS CALCULATION EXAMPLE

The natural gas savings for a 120 pound per load tunnel washer where the estimated annual loads are estimated to be 30 loads per hour for 8 hours a day for 350 days a year can be calculated in the following fashion.

The annual number of loads is:

$$Annual\ Loads = 30\frac{loads}{hr} \times 8\frac{hr}{day} \times 350\frac{days}{yr} = 84{,}000\frac{loads}{yr}$$

The annual natural gas savings are:

$$\Delta(m^3) = 0.0293\frac{(m^3 yr)}{lb} \times 120\frac{lb}{load} \times 84{,}000\frac{loads}{yr} = 295{,}344\ m^3$$

The annual electric and water savings can be calculated similarly to be:

$$Electric\ savings = 15{,}120\ kWh/yr$$

$$Water\ savings = 12{,}801{,}600\ L/yr$$

USES AND EXCLUSIONS:

Residential-style clothes washers do not qualify for this measure. Commercial washers that process heavily soiled laundry do not qualify for this measure because of the higher water temperatures utilized.

MEASURE LIFE:

The measure life is 15 years [2].

INCREMENTAL COST:

Table 4 shows the incremental costs associated with the two different types of washers and grouped into two different sized bins each.

Table 4: Incremental Costs [2] [6] [7] [8]

Washer Type	Incremental Cost
Washer extractor – ≤ 60 lbs	$11,000
Washer extractor – > 60 lbs and < 500 lbs	$25,000
Washer extractor – ≥ 500 lbs	$31,000
Tunnel washer – ≤ 120 lbs	$50,000
Tunnel washer – > 120 lbs and < 500 lbs	$105,000
Tunnel washer – ≥ 500 lbs	$160,000

Capital and installation incremental costs were obtained from interviews with manufacturer sales representatives. Please note that installed system costs can be highly variable, especially for the tunnel washer systems which tend to be custom installations. The size and cost of the ozone system are primarily determined by the amount of water being used and the level of soil in the laundry, but can also be affected by the type and arrangement of the washers.

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ENERGY STAR DISHWASHERS

DATE: 8/26/14

TO: Ontario TEC Sub-Committee

FROM: ERS

RE: ENERGY STAR Dishwashers – New Construction and Time of Natural Replacement

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This technical reference manual (TRM) section is based on the review of supporting documents including:

- A single substantiation sheet that applies to both new construction and retrofit measure categories;
- A commercial dishwasher calculation spreadsheet provided by Enbridge;
- Other relevant program TRMs;
- The current Canadian ENERGY STAR documentation;
- And, documentation of dishwasher performance from the Food Service Technology Center.

There are no differences between new construction and retrofit measures in the baseline and energy efficient technology assumptions or energy savings calculations in the supporting documents for this measure. This is appropriate as dishwashers are typically replaced at, or near, the time of failure.

ERS has based the revised analysis approach on current ENERGY STAR methodology and results. This is consistent with approaches documented in other program's technical reference manuals. The Canadian ENERGY STAR documentation references the U.S. data and is the source of the baseline and energy efficient assumptions.

The categorization for the measure is:

Commercial → ENERGY STAR Dishwashers→ NC and TNR

ENERGY STAR DISHWASHERS – ALL MEASURE CATEGORIES

Version Date and Revision History	
Draft date	8/26/2014
Effective date	TBD
End date	TBD
Commercial → ENERGY STAR→ New Construction and Time of Natural Replacement	

This measure is for the installation of a new, ENERGY STAR-rated dishwasher for commercial use. Table 1 shows the key measure parameters including the deemed savings for each type of dishwasher.

Table 1. Measure Summary

Parameter	Definitions			
Measure Category	New Construction and Time of Natural Replacement			
Baseline Technology	Table 2			
Efficient Technology	Table 3			
Energy Savings (Dependent on Type of Dishwasher Installed)	**Dishwasher Type**	**Savings per Year**		
		Gas (m^3)	**Electric (kWh)**	**Water (L)**
	High Temperature			
	Under Counter	142	1,790	20,371
	Stationary Single Tank Door	922	4,167	132,263
	Single Tank Conveyor	560	4,247	80,303
	Multi Tank Conveyor	2,124	9,668	304,677
	Low Temperature			
	Under Counter	333	0	47,827
	Stationary Single Tank Door	2,120	0	304,205
	Single Tank Conveyor	1,712	0	245,631
	Multi Tank Conveyor	2,469	0	354,276
Measure life	**Dishwasher Type**	**High and Low Temperature (years)**		
	Under Counter	10		
	Stationary Single-Tank Door	15		
	Single-Tank Conveyor	20		
	Multi-Tank Conveyor	20		

Parameter	Definitions		
Incremental cost	**Dishwasher Type**	**High Temperature**	**Low Temperature**
	Under Counter	$120	$50
	Stationary Single-Tank Door	$770	$0
	Single-Tank Conveyor	$2,050	$0
	Multi-Tank Conveyor	$970	$970

OVERVIEW

Dishwasher types are broken into two primary categories: high temperature and low temperature. High temperature dishwashers use a booster water heater to heat the already hot tap water to a minimum of 180°F [1] as required by the National Sanitation Foundation (NSF) Standard No. 3 [2]. At these temperatures, hard-to-remove residues like lipstick and grease are dissolved without the need for additional sanitizing chemicals. These 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. Low temperature dishwashers are less expensive than high temperature models. For this measure, booster heaters are assumed to be electric, as they are most prevalent, although natural gas booster heaters are available.

Besides high and low temperature categories, dishwashers can be further categorized by the volume of dishes or the number of racks they handle. Types of dishwashers in order of increasing capacity are: under-counter, stationary rack, and rack conveyer. Under-counter types are similar to residential dishwashers and can handle up to 35 racks per hour. Stationary rack or pull-down-hood dishwashers are suitable for small commercial settings and can handle up to 80 racks an hour. Conveyer dishwashers pull racks through on a conveyer system and can handle up to 400 racks per hour [3].

Conveyer-type dishwashers are configured with either one tank for circulation water or several; one for each stage of the wash cycle (wash, rinse, and sanitize). Multiple-tank dishwashers can handle up to 600 racks per hour and have different ENERGY STAR requirements from their single-tank counterparts.

ENERGY STAR-qualified dishwashers are performance rated for water use per rack and idle power draw. Each type of dishwasher has its own product qualification criteria as outlined in Table 3. The water consumption values are a key component used in the calculation of energy consumption for dishwashers.

New Construction or Time of Natural Replacement Projects

Installing ENERGY STAR-rated dishwashers in new construction projects or at the end of the existing equipment's useful life will result in natural gas savings from the increased washing efficiency. The washing efficiency and energy savings are primarily derived from the reduced use of hot water.

APPLICATION

This measure provides incentives for installing ENERGY STAR-rated dishwashers in a commercial setting.

BASELINE TECHNOLOGY

Non-ENERGY STAR-rated dishwashers are assumed to have the parameters shown in Table 2. The baseline value is derived from the ENERGY STAR commercial kitchen equipment calculator, which cites EPA/Food Service Technology Center's equipment specification research, 2013, as their source.

Table 2. Baseline Values for Commercial Dishwashers [4]

Machine Type	High Temperature Efficiency		Low Temperature Efficiency	
	Idle Energy Rate (kW)[1]	Water Consumption (GPR)[2]	Idle Energy Rate (kW)[1]	Water Consumption (GPR)[2]
Under Counter	0.76	1.09	0.50	1.73
Stationary Single Tank Door	0.87	1.29	0.60	2.10
Single Tank Conveyor	1.93	0.87	1.50	1.31
Multiple Tank Conveyor	2.59	0.97	2.00	1.04

[1] Idle results should be measured with the door closed and represent the total idle energy consumed by the machine including all tank heater(s) and controls. Booster heater (internal or external) energy consumption should not be part of this measurement unless it cannot be separately monitored per the ENERGY STAR test method [5].

[2] GPR = gallons per rack

EFFICIENT TECHNOLOGY

ENERGY STAR-rated dishwashers must have idle energy and water consumption rates as defined in Table 3.

Table 3. ENERGY STAR Energy Efficiency Requirements for Commercial Dishwashers [5]

Machine Type	High Temperature Efficiency Requirements		Low Temperature Efficiency Requirements	
	Idle Energy Rate (kW)[1]	Water Consumption (GPR)[2]	Idle Energy Rate (kW)[1]	Water Consumption (GPR)[2]
Under Counter	≤ 0.50 kW	≤ 0.86 GPR	≤ 0.50 kW	≤ 1.19 GPR
Stationary Single Tank Door	≤ 0.70 kW	≤ 0.89 GPR	≤ 0.60 kW	≤ 1.18 GPR

Machine Type	High Temperature Efficiency Requirements		Low Temperature Efficiency Requirements	
	Idle Energy Rate (kW)[1]	Water Consumption (GPR)[2]	Idle Energy Rate (kW)[1]	Water Consumption (GPR)[2]
Single Tank Conveyor	≤ 1.50 kW	≤ 0.70 GPR	≤ 1.50 kW	≤ 0.79 GPR
Multiple Tank Conveyor	≤ 2.25 kW	≤ 0.54 GPR	≤ 2.00 kW	≤ 0.54 GPR

[1] Idle results should be measured with the door closed and represent the total idle energy consumed by the machine including all tank heater(s) and controls. Booster heater (internal or external) energy consumption should not be part of this measurement unless it cannot be separately monitored per the ENERGY STAR Test Method [5].
[2] GPR = gallons per rack

ENERGY IMPACTS

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.

NATURAL GAS AND ELECTRICAL SAVINGS ALGORITHMS

The following algorithms are referenced from the ENERGY STAR Commercial Kitchen Equipment Calculator for dishwashers.

The natural gas savings are a function of the water saved by the energy efficient technology, and the electrical savings are a result of lower idle energy rates. It is notable that the baseline and ENERGY STAR low temperature dishwashers have the same idle energy rates, which results in zero electricity savings.

First, the heat input required to raise the water to the desired temperature (Q_{in}) is calculated on a per gallon basis. Next, the annual water consumption is calculated for both the baseline and ENERGY STAR-rated dishwashers based on the water use per rack (GPR) and the number of racks washed per day (RPD). Finally the fuel savings are calculated using results from the previous calculations.

Starting with the calculation for the water heater specific energy consumption:

$$Q_{In} = T_{Inc} \times C_P \times \frac{\rho}{Eff_{Gas}}$$

where,

Q_{In} = Water heater specific energy consumption (Btu/gal)

T_{Inc} = Temperature increase required by building heating system for supply water (see Table 4, °F)

C_P = The specific heat of water (see Table 4, Btu/lb °F)

ρ = The density of water (see Table 4, lb/gal)

Eff_{Gas} = Building water heating system efficiency (see Table 4, %)

The annual water consumption can be calculated as:

$$Annual\ water\ consumption = GPR \times RPD \times Days$$

where,

$Annual\ water\ consumption$ = Annual water consumption of the dishwasher (gallons/year)

GPR = Gallons per rack water consumption of dishwasher (see Tables 2 and 3, gal/rack)

RPD = Racks washed per day (see Table 5, racks/day)

$Days$ = Annual days of operation (see Table 4, days/year)

The annual fuel consumption can be calculated as:

$$Annual\ fuel\ consumption = Annual\ water\ consumption \times Q_{In}$$

where,

$Annual\ fuel\ consumption$ – Annual fuel consumption to heat water for the dishwasher (MMBtu)

The fuel savings can be calculated as the difference between the baseline and energy efficiency calculated annual fuel consumptions.

$$Fuel\ savings = Annual\ fuel\ consumption_{Base} - Annual\ fuel\ consumption_{EE}$$

where,

Base refers to the annual fuel consumption for the baseline technology.

EE refers to the annual fuel consumption for the energy efficient technology.

Dishwashers use electricity while idle, called the idle energy rate (IER), and are performance rated for this parameter by ENERGY STAR. The electricity consumption of a dishwasher can be calculated from the idle energy rate and by calculating the amount of time that the machine spends idle.

$$Elec = IER \times (Hrs \times Days - Days \times RPD \times \frac{TWT}{60})$$

where,

$Elec$ = Annual electricity consumption (kWh)

IER = Idle energy rate (see Tables 2 and 3, kW)

Hrs = Average daily operation (see Table 4, hours)

$Days$ = Annual days of operation (see Table 4, days/year)

RPD = Racks washed per day (see Table 5, racks/day)

TWT = Typical wash time (see Table 6, minutes)

For high temperature models there is also an electric component that is attributable to the booster heater, which is responsible for heating the supply water from 140°F to 180°F. The energy required to heat the water the additional 40°F is calculated in a way similar to that for the primary natural gas water heater by first calculating the kWh per gallon required to raise the temperature of the water the desired amount.

$$Q_{Boost} = \frac{T_{Boost} \times C_P \times \rho}{Eff_{Elec} \times 3{,}413\ Btu/kWh}$$

where,

Q_{Boost} = Energy required to raise the temperature of the water from the primary water heater set point to the high temperature set point of the booster heater (kWh/gallon)

T_{Boost} = The temperature difference between the primary water heater setpoint and the booster heater high temperature setpoint (see Table 4, °F)

C_P = The specific heat of water (see Table 4, Btu/lb °F)

ρ = The density of water (see Table 4, lb/gal)

Eff_{Elec} = The efficiency of the electrical booster heater (see Table 4, %)

$3{,}413 \frac{Btu}{kWh}$ = The conversion factor for kilowatt hours (kWh) British thermal units (Btus)

The electrical energy attributable to the booster heater can be calculated by multiplying the kWh per gallon required to raise the temperature of the water to 180°F by the annual water consumption.

$$Elec_{Boost} = Q_{Boost} \times Annual\ water\ consumption$$

The electrical savings can be calculated by tabulating electrical consumption for both the base and energy efficient models from the idle energy equation and the booster heater if a high temperature model.

$$Elec\ savings = Elec_{Base} - Elec_{EE}$$

where,

Elec savings = Annual electricity savings for the measure (kWh)

$Elec_{Base}$ = Annual electricity consumption for the baseline dishwasher, including the booster heater contribution if a high temperature model (kWh)

$Elec_{EE}$ = Annual electricity consumption for the ENERGY STAR dishwasher, including the booster heater contribution of a high temperature model (kWh)

LIST OF ASSUMPTIONS

Table 4 shows the list of conversions utilized in the measure savings algorithm.

Table 4. Assumptions

Variable	Definition	Inputs for Baseline and Energy Efficient Options	Source/Comments
C_P	Specific heat of water	1.00 Btu/lb˚F	Common assumptions table
ρ	Water density	8.28 lb/gal (US)	Common assumptions table
	City supply water temperature	48.9°F	Common assumptions table
	Commercial hot water tank temperature	140°F	Common assumptions table
T_{Inc}	Temperature delta that building heating system will need to heat city supply water to feed hot water tank	91.1˚F	T_{inc}=140°F – 48.9°F
	Energy density of natural gas	0.03574 m^3/MMBtu	Common assumptions table
T_{Boost}	Temperature difference that needs to be met by booster heater	40˚F	[5]
Eff_{Gas}	Gas water heating system efficiency	80%	Common assumptions table
Eff_{Elec}	Electric booster heater efficiency	98%	[6]
Hrs	Average daily operation	18 hrs	[6]
Days	Annual days of operation	312 days	6 days per week for 52 weeks is 312 days [7]

ENERGY STAR uses the assumptions in Table 5 for racks washed per day.

Table 5. Assumptions for Racks Washed Per Day [6]

Dishwasher Type	High and Low Temperature
Under counter	75
Stationary single-tank door	280
Single-tank conveyor	400
Multi-tank conveyor	600

ENERGY STAR uses the assumptions in Table 6 for typical wash times.

Table 6. Assumptions for Typical Wash Time Minutes [6]

Dishwasher Type	High Temperature	Low Temperature
Under counter	2.0	2.0
Stationary single-tank door	1.0	1.5
Single-tank conveyor	0.3	0.3

Dishwasher Type	High Temperature	Low Temperature
Multi-tank conveyor	0.2	0.3

There are two considerations that should be taken into account before making the savings calculations:

1. All high temperature boosters are assumed to be electric.
2. Primary water heating systems are assumed to be natural gas.

SAVINGS CALCULATION EXAMPLE

The example below shows how the savings would be calculated for the measure. For the example, it will be assumed that an ENERGY STAR-rated low temperature single-tank conveyor dishwasher will be installed.

The heat required to raise the temperature of the water to the desired point (constant for all dishwasher types):

$$Q_{In} = \frac{91.1^{\circ}\ F \times 1 \frac{Btu}{lb}{}^{\circ}\ F \times 8.28 \frac{lb}{gal} \div}{0.80 \times 35{,}738\ Btu/m^3} = 0.02638\ m^3/US\ gal$$

Then the annual water consumption can be calculated for the ENERGY STAR-rated dishwasher as:

$$Annual\ water\ consumption_{EE} = 0.79\ gal/rack \times 400\ racks/day \times 312\ days/year$$
$$= 98{,}592\ gallons\ per\ year$$

The conventional water consumption can be calculated similarly as:

$$Annual\ water\ consumption_{Base} = 163{,}488 \text{ gallons per year}$$

Energy efficient fuel consumption can be calculated as follows:

$$Annual\ fuel\ consumption_{EE} = 98{,}592 \times 0.02638 = 2{,}601 \frac{m^3}{yr}$$

$$Annual\ fuel\ consumption_{Base} = 191{,}260 \times 0.02638 = 4{,}312 \frac{m^3}{yr}$$

Annual fuel savings:

$$Fuel\ savings = 4{,}312 \frac{m^3}{yr} - 2{,}601 \frac{m^3}{yr} = 1{,}712 \frac{m^3}{yr}$$

The low temperature dishwashers do not have any electricity savings.

USES AND EXCLUSIONS

The installed dishwasher must be ENERGY STAR-qualified and installed in a commercial setting.

MEASURE LIFE

Table 7 shows the measure lifetimes for each type of dishwasher

Table 7. Equipment Lifetime (Years) [5] [8]

Dishwasher Type	High and Low Temperature
Under counter	10
Stationary single-tank door	15
Single-tank conveyor	20
Multi-tank conveyor	20

The equipment lifetimes were derived from the Food Service Technology Center (FSTC), which contributed to the development of the ENERGY STAR U.S. calculator. No lifetime distinction was identified relative to the sanitation method (high or low temperature) or to the efficiency (ENERGY STAR-qualified or not) of the dishwashers.

INCREMENTAL COST

Table 8 shows the equipment incremental costs for each type of dishwasher.

Table 8. Incremental Costs [9]

Dishwasher Type	High Temperature	Low Temperature
Under counter	$120	$50
Stationary single-tank door	$770	$0
Single-tank conveyor	$2,050	$0
Multi-tank conveyor	$970	$970

Incremental costs were obtained from the ENERGY STAR commercial kitchen equipment energy savings calculator, the costs of which were obtained from EPA research using AutoQuotes, 2012.

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