Supplementary Material: A Methodology for Constructing Marginal Abatement Cost Curves for Climate Action in Cities

Nadine Ibrahim and Christopher Kennedy

Sensitivity Analysis

Inherent in the construction of the MAC curves, and in the methodology for determining marginal abatement costs and abatement potentials are numerous assumptions and uncertainties. A sensitivity analysis is useful to offer a measure of the uncertainty, and is limited here to discount rate, being one of the main parameters driving cost-effectiveness calculations, as summarized in Table S1.

Table S1. Sensitivity of the discount rate on the lowest and highest cost-effectiveness of the mitigation measures on the MAC curve.

Parameter	Impact on Lowest and Highest Cost-Effectiveness							
Discount rate	3%		4%		6%		7%	
Cost-Effectiveness ($/tCO$_2$)	1ow	high	low	high	low	high	low	high
	−697	2052	−677	2222	−642	2,540	−626	2692
(Baseline at 5%) Low	−658							
(Baseline at 5%) High	2384							
% change	5.9	−13.9	2.9	−6.8	−2.4	6.5	−4.9	12.9

As the discount rate decreases, mitigation measures offering financial savings appear to offer more savings, and measures that are not economically viable appear to be more attainable. The opposite is true as the discount rate increases, where mitigation measures offer financial savings, they appear to offer less, and costly measures appear less viable.

It is worthwhile to note that sensitivity of the results to the discount rate does not change the prioritization of the mitigation measures but only makes them, as a whole package, more or less financially attractive. However, assessing the sensitivity to other measures of a financial nature including the price of electricity, natural gas, gasoline, and diesel would be worthwhile particularly that the reprioritizing of the mitigation measures analyzed may have useful policy implications to consider. However, the MAC curve model in its current form does not support reprioritization for changing input prices, but rather prices are held constant throughout the analysis. Likewise, sensitivity for the input data for capital costs of the mitigation measures and reference technology is not possible on a measure-by-measure basis. The baseline prices used in the MAC curve calculations are as follows:

- electricity for residential application: 10.4 cents/kWh
- electricity for commercial application: 12.2 cents/kWh
- natural gas for residential application: 40.6 cents/m^3
- natural gas for commercial application: 30.7 cents/m^3
- gasoline: 128.5 cents/L
- diesel: 124.8 cents/L

Table S2. Economic costs and GHG emission inputs of mitigation measures in the energy supply sector.

No.	Mitigation Measure	Reference Technology Including Specifications	Life (years)	Capacity Utilization	Economic Cost Inputs and Assumptions	References for Economic Costs and Lifetime	Emission Factor (gCO_2e/kWh)	References for Energy Savings
0	SCGT (Fossil Fuel)	Baseline Technology	20	Capacity Utilization: 7400 h (Max)	$665 (2008)/kW (Capital) $16.0 (2008)/kW (Fixed O&M) $3.5 (2008)/MWh (Variable O&M) $8.9 USD(2010)/GJ (Average Fuel Price)	[1,2]	370 (Median direct emissions)	[2]
1	Biogas (Biofuel)	SCGT	20	Capacity Utilization: 7000 h (Max)	$2096 (2008)/kW (Capital Cost) $231.0 (2008)/kW (Fixed O&M) $27.0 (2008)/MWh (Variable O&M) $6.3 USD(2010)/GJ (Average Fuel Price)	[1,2]	0	[2]
2	Hydropower RR (Renewable)	SCGT	50	Capacity Utilization: 7900 h (Max)	$3570 (2008)/kW (Capital) $41.8 (2008)/kW (Fixed O&M) $0 (2008)/MWh (Variable O&M)	[1]	0	[2]
3	Hydro DIS (Renewable)	SCGT	50	Capacity Utilization: 7900 h (Max)	$2550 (2008)/kW (Capital) $41.8 (2008)/kW (Fixed O&M) $0 (2008)/MWh (Variable O&M)	[1]	0	[2]
4	Nuclear	SCGT	40	Capacity Utilization: 7400 h (Max)	$2907 (2008)/kW (Capital) $108.1 (2008)/kW (Fixed O&M) $3.1 (2008)/MWh (Variable O&M) $0.805 USD(2010)/GJ (Average Fuel Price)	[1,2]	0	[2]
5	Wind (Renewable)	SCGT	20	Capacity Utilization: 3500 h(Max)	$1938 (2008)/kW (Capital) $47.9 (2008)/kW (Fixed O&M) $0 (2008)/MWh (Variable O&M)	[1]	0	[2]
6	Solar (Renewable)	SCGT	20	Capacity Utilization: 2400 h (Max)	$5712 (2008)/kW (Capital) $13.3 (2008)/kW (Fixed O&M) $0 (2008)/MWh (Variable O&M)	[1]	0	[2]

1. If not stated otherwise, costs are in Canadian Dollars; 2. 1USD = 1.2CDN; 3. SCGT = Simple Cycle Gas Turbine; RR = Regulating Reserves; DIS = Distributed.

Table S3. Cost-effectiveness and GHG abatement of mitigation measures in the energy supply sector.

No.	Mitigation Measure	Cost-Effectiveness 2012 ($/tCO$_2$)	GHG Abatement Assumptions	References for Abatement Assumptions	GHG Abatement Assumptions in 2020	GHG Abatement in 2020 (tCO$_2$)	GHG Abatement Assumptions in 2050	GHG Abatement in 2050 (tCO$_2$)
1	Biogas (Biofuel)	56.57	3% of Energy Supply in 2025	[3]	298,242	3% of Energy Supply in 2025	[3]	565,426
2	Hydropower RR (Renewable)	69.65	14.5% of Energy Supply in 2025	[3]	1,441,502	14.5% of Energy Supply in 2025	[3]	2,732,892
3	Hydropower DIS (Renewable)	60.09	14.5% of Energy Supply in 2025	[3]	1,441,502	14.5% of Energy Supply in 2025	[3]	2,732,892
4	Nuclear	71.03	42% of Energy Supply in 2025	[3]	4,175,384	42% of Energy Supply in 2025	[3]	7,915,963
5	Wind (Renewable)	190.58	11% of Energy Supply in 2025	[3]	1,093,553	11% of Energy Supply in 2025	[3]	2,073,228
6	Solar (Renewable)	424.12	3% of Energy Supply in 2025	[3]	298,242	3% of Energy Supply in 2025	[3]	565,426

Table S4. Economic costs and GHG emission inputs of mitigation measures in the building sector.

No.	Mitigation Measure	Reference Technology	Sub-sector	Economic Cost Inputs and Assumptions of Mitigation Measure	References for Economic Costs	Economic Cost Inputs and Assumptions of Reference Technology	References for Economic Costs
1	Photovoltaics (Residential)	None. Existing Energy Supply	Residential (Low-Rise)	$11 (2008)/W (Mean Capital Cost) Power Capacity: 3.2 kW Negligible incremental O&M Costs Assumed building size: 190 m^2 Annual Energy Output/Savings: 4.2 MWh 30 year lifetime	[4,5]	N/A	N/A
2	Photovoltaics (Commercial-Small Business)	None. Existing Energy Supply	Commercial/Institutional	$9.5 (2008)/W (Mean Capital Cost) Power Capacity: 18 kW Negligible incremental O&M Costs Assumed building size: 930 m^2 Annual Energy Output/Savings: 23 MWh 30 year lifetime	[4,5]	N/A	N/A

Table S4. *Cont.*

No.	Mitigation Measure	Reference Technology	Sub-sector	Economic Cost Inputs and Assumptions of Mitigation Measure	References for Economic Costs	Economic Cost Inputs and Assumptions of Reference Technology	References for Economic Costs
3	Photovoltaics (Commercial/ Institutional)	None. Existing Energy Supply	Commercial/ Institutional	$9.5 (2008)/W (Mean Capital Cost) Power Capacity: 120 kW Negligible incremental O&M Costs Assumed building size: 1500 m² Annual Energy Output/Savings: 150 MWh 30 year lifetime	[4,5]	N/A	N/A
4	Solar Air Heater (Residential) NG Home	Natural Gas Furnace	Residential (Low-Rise)	$370 (2008)/m² (Mean Capital Cost) Collector Area: 4 m² Negligible incremental O&M Costs Assumed building size: 190 m² Offsets 80% of heating system 35 year lifetime	[4,6]	$2750 (2015) (Capital and Installation Costs); 80% AFUE Standard Efficiency; 60,000 BTU Continuous Furnace Fan Motor (720 h monthly in winter; 6 months); 18 year lifetime	[7–9]
5	Solar Air Heater (Residential) E Home	Electric Heat Pump	Residential (Low-Rise)	$370 (2008)/m² (Mean Capital Cost) Collector Area: 4 m² Negligible incremental O&M Costs Assumed building size: 190 m² Offsets 80% of heating system 35 year lifetime	[4,6]	$4910 USD (2015) (Capital and Installation Costs); 10 kW Heat Pump (160 h monthly in winter; 6 months); 15 year lifetime	[8–10]
6	Solar Air Heater (Commercial-Small Business) NG SB	Natural Gas Furnace	Commercial	$370 (2008)/m² (Mean Capital Cost) Collector Area: 40 m² Negligible incremental O&M Costs Assumed building size: 930 m² 35 year lifetime	[4,6]	$9000 (2015) (Capital and Installation Costs) 80% AFUE Standard 160,000 BTU 78% AFUE 18 year lifetime	[7,8,11]
7	Solar Air Heater (Commercial-Small Business) E SB	Electric Furnace	Commercial	$370 (2008)/m² (Mean Capital Cost) Collector Area: 4m² Negligible incremental O&M Costs Assumed building size: 190 m² 35 year lifetime	[4,6]	$10,510 USD (2015) (Capital per unit and Installation Costs) 5 × 20 kW Heat Pump (160 h monthly in winter; 6 months) 15 year lifetime	[8,10]

Table S4. *Cont.*

No.	Mitigation Measure	Reference Technology	Sub-sector	Economic Cost Inputs and Assumptions of Mitigation Measure	References for Economic Costs	Economic Cost Inputs and Assumptions of Reference Technology	References for Economic Costs
8	ENERGY STAR Natural Gas Furnace NG Home	Standard Natural Gas Furnace	Residential (Low-Rise)	$8750 (2014) Capital Cost and Installation 60,000 BTU (98%AFUE) Intermittent Furnace Fan Motor (160 h monthly in winter; 6 months)	[7,8]	$7300 (2014) Capital Cost and Installation 60,000 BTU (82% AFUE) Intermittent Furnace Fan Motor (160 h monthly in winter; 6 months) 18 year lifetime	[7,8]
9	Electric Heat Pump NG Home	Standard Natural Gas Furnace	Residential (Low-Rise)	$4910 USD (2015) (Capital and Installation Costs) 10 kW Heat Pump (160 h monthly in winter; 6 months) 15 year lifetime	[8–10]	$7300 (2014) Capital Cost and Installation 60,000BTU (82% AFUE) Intermittent Furnace Fan Motor (160 h monthly in winter; 6 months) 18 year lifetime	[7,8]
10	Solar Water Heater (Replacing Electric Storage Water Heater) (Residential) E Home	Electric Storage Water Heater	Residential (Low-Rise)	$1000 (2008)/m^2 (Mean Capital Cost) Collector Area: 6 m^2 Negligible incremental O&M Costs Assumed building size: 190 m^2 80% solar usage annually 25 year lifetime	[4,12,13]	$950 USD(2005) (Average Capital & Installation) 5 kW (40 Gal capacity) 118h of use monthly 10 year lifetime	[9,14]
11	Solar Water Heater (Replacing Natural Gas Storage Water Heater) (Residential) NG Home	Gas Storage Water Heater	Residential (Low-Rise)	$1000 (2008)/m^2 (Mean Capital Cost) Collector Area: 6 m^2 Negligible incremental O&M Costs Assumed building size: 190 m^2 80% solar usage annually 25 year lifetime	[4,12,13]	$1137.50 USD (2005) (Average Capital & Installation) 40,000 BTU hourly (40 Gal capacity) 0.75 Efficiency Factor 118h of use monthly 10 year lifetime	[9,14]

Table S4. *Cont.*

No.	Mitigation Measure	Reference Technology	Sub-sector	Economic Cost Inputs and Assumptions of Mitigation Measure	References for Economic Costs	Economic Cost Inputs and Assumptions of Reference Technology	References for Economic Costs
12	Solar Water Heater (Replacing Electric Storage Water Heater) (Commercial-Small Business) E SB	Electric Storage Water Heater	Commercial/Institutional	$1000 (2008)/m² (Mean Capital Cost) Collector Area: 8 m² Negligible incremental O&M Costs Assumed building size: 930 m² 25 year lifetime	[4,13]	$2004 USD (2015) 6kW (80 Gal capacity) 10 year lifetime	[14–16]
13	Solar Water Heater (Replacing Natural Gas Storage Water Heater) (Commercial - Small Business) E SB	Gas Storage Water Heater	Commercial/Institutional	$1000 (2008)/m² (Mean Capital Cost) Collector Area: 8 m² Negligible incremental O&M Costs Assumed building size: 930 m² 25 year lifetime	[4,13]	$2394 USD (2015) 75,000 BTU hourly (75 Gal capacity) 0.8 Efficiency Factor Usage 12h/day assumed 10 year lifetime	[14,17]
14	Solar Water Heater (Replacing Electric Storage Water Heater) (Commercial/Institutional) E C/I	Electric Storage Water Heater	Commercial/Institutional	$1000 (2008)/m² (Mean Capital Cost) Collector Area: 46 m² Negligible incremental O&M Costs Assumed building size: 1500 m² 25 year lifetime	[4,13]	$6076 USD(2015) 45 kW (120 Gal capacity) 10 year lifetime	[14,15,16]
15	Solar Water Heater (Replacing Natural Gas Storage Water Heater) (Commercial/Institutional) NG C/I	Gas Storage Water Heater	Commercial/Institutional	$1000 (2008)/m² (Mean Capital Cost) Collector Area: 46 m² Negligible incremental O&M Costs Assumed building size: 1500 m² 25 year lifetime	[4,13]	$7,942USD(2015) 250,000 BTU hourly (120 Gal capacity) 0.8 Efficiency Factor Usage 12h/day assumed 10 year lifetime	[14,15,18]

Table S4. *Cont.*

No.	Mitigation Measure	Reference Technology	Sub-sector	Economic Cost Inputs and Assumptions of Mitigation Measure	References for Economic Costs	Economic Cost Inputs and Assumptions of Reference Technology	References for Economic Costs
16	Wind (Residential)	None. Existing Energy Supply	Residential (Low-Rise)	$6.8 (2008)/W (Mean Capital Cost) Power Capacity: 2.6 kW $335 (2008)/building (Annual O&M Costs) Assumed building size: 190 m² Annual Energy Output/Savings: 4.9 MWh 25 year lifetime	[4,19]	None.	-
17	Wind (Commercial-Small Business)	None. Existing Energy Supply	Commercial/Institutional	$6.2 (2008)/W (Mean Capital Cost) Power Capacity: 10kW $1237 (2008)/building (Annual O&M Costs) Assumed building size: 930 m² Annual Energy Output/Savings: 12 MWh 25 year lifetime	[4,19]	None.	-
18	Wind (Commercial/ Institutional)	None. Existing Energy Supply	Commercial/Institutional	$3.6 (2008)/W (Mean Capital Cost) Power Capacity: 50 kW $3550 (2008)/building (Annual O&M Costs) Assumed building size: 1500 m² Annual Energy Output/Savings: 130 MWh 25 year lifetime	[4,19]	None.	-
19	ENERGY STAR High Efficiency Electric Storage Water Heater E Home	Standard Electric Water Tank Heater	Residential (Low-Rise)	$1640 USD (2015) (Average Capital & Installation) 4.5 kW (40 Gal capacity) 118 h of use monthly 10 year lifetime	[9,14,16]	$950 USD(2005) (Average Capital & Installation) 5 kW (40 Gal capacity) 118 h of use monthly 10 year lifetime	[9,14]

Table S4. *Cont.*

No.	Mitigation Measure	Reference Technology	Sub-sector	Economic Cost Inputs and Assumptions of Mitigation Measure	References for Economic Costs	Economic Cost Inputs and Assumptions of Reference Technology	References for Economic Costs
20	ENERGY STAR High Efficiency Electric Storage Water Heater (Heat Pump) E Home	Standard Electric Water Tank Heater	Residential (Low-Rise)	$4528 USD (2014) (Average Capital & Installation) 2195 kWh/year 20 year lifetime	[14,20]	$950 USD (2005) (Average Capital & Installation) 5kW (40 Gal capacity) 118 h of use monthly 10 year lifetime	[9,14,21]
21	ENERGY STAR Whole Home Gas Tankless Water Heater NG Home	Standard Gas Storage Water Heater	Residential (Low-Rise)	$1420 USD (2015) (Average Capital & Installation) 30% less than standard gas storage models 20 year lifetime	[14,20,22]	$1137.50 USD(2005) (Average Capital & Installation) 40,000 BTU hourly (40 Gal capacity) 0.75 Efficiency Factor 118 h of use monthly 10 year lifetime	[9,14]
22	ENERGY STAR High-Efficiency Gas Storage Water Heater NG Home	Standard Gas Storage Water Heater	Residential (Low-Rise)	$2044USD (2015) (Average Capital & Installation) 14% less than standard gas storage models 10 year lifetime	[14,17,20]	$1137.50 USD (2005) (Average Capital & Installation) 40,000 BTU hourly (40 Gal capacity) 0.75 Efficiency Factor 118h of use monthly 10 year lifetime	[9,14]
23	ENERGY STAR High Efficiency Electric Storage Water Heater (Heat Pump) NG Home	Standard Gas Storage Water Heater	Residential (Low-Rise)	$4528 USD (2014) (Average Capital & Installation) 2195 kWh/year 20 year lifetime	[14,20]	$1137.50 USD (2005) (Average Capital & Installation) 40,000 BTU hourly (40 Gal capacity) 0.75 Efficiency Factor 118 h of use monthly 10 year lifetime	[9,14]

Table S4. *Cont.*

No.	Mitigation Measure	Reference Technology	Sub-sector	Economic Cost Inputs and Assumptions of Mitigation Measure	References for Economic Costs	Economic Cost Inputs and Assumptions of Reference Technology	References for Economic Costs
24	ENERGY STAR Refrigerator	Standard Refrigerator	Residential (LR and MUR)	$765 (2015) 382 kWh annual 11 year lifetime	[23–25]	$729 (2014) 664kWh annual 11 year lifetime	[23–25]
25	ENERGY STAR Clothes Dryer (Electric) E Home	Standard Electric Clothes Dryer Electric	Residential (LR and MUR)	$1500 (2011) 684 kWh annual 14 year lifetime	[26]	$1015 USD (2013) 967 kWh annual 14 year lifetime	[26,27]
26	ENERGY STAR Clothes Dryer (Gas) NG Home	Standard Gas Clothes Dryer	Residential (Low-Rise)	$1500 (2011) 748 kWh annual 14 year lifetime	[26]	$1150 USD (2013) 1091 kWh annual 14 year lifetime	[26,27]
27	ENERGY STAR Dishwasher	Standard Dishwasher	Residential (LR and MUR)	$1,274 (2015) 322 kWh annual 9 year lifetime	[23–25]	$949 (2014) 649 kWh annual 9 year lifetime	[23–25]
28	ENERGY STAR Clothes Washer	Standard Clothes Washer	Residential (LR and MUR)	$799 (2015) 251 kWh annual 14 year lifetime	[24]	$699 (2014) 930 kWh annual 14 year lifetime	[24]
29	ENERGY STAR Light Bulbs (LED)	Incandescent	Residential (Low-Rise)	$9.99USD(2015) 9 W; 50,000 h Usage assumed 3 h/day	[28–31]	$1.50 USD (2015) 40W; 1,200 h Usage assumed 3 h/day	[28–31]
30	ENERGY STAR Light Bulbs (CFL)	Incandescent	Residential (Low-Rise)	$5.93USD(2015) 26 W; 8000 h Usage assumed 3 h/day Toronto values from CHMC: Cooling reduced by 19% (average of 15%-22%) Heating increased by 0.6%–1.7%, considered negligible Cost saving reduced by 40%	[28,30–32]	$1.50 USD (2015) 40 W; 1200 h Usage assumed 3 h/day	[28,30,31]
31	ENERGY STAR Light Bulbs (LED)	Incandescent	Residential (MUR)	$11.98 (2015) 12 W; 50,000 h Usage assumed 3 h/day	[28,29,31]	$2.16 USD(2015) 65 W; 1,200 h Usage assumed 3 h/day	[28,29,31]

Table S4. *Cont.*

No.	Mitigation Measure	Reference Technology	Sub-sector	Economic Cost Inputs and Assumptions of Mitigation Measure	References for Economic Costs	Economic Cost Inputs and Assumptions of Reference Technology	References for Economic Costs
32	ENERGY STAR Light Bulbs (CFL)	Incandescent	Residential (MUR)	$5.93 USD (2015) 26 W; 8000 h Usage assumed 3 h/day Toronto values from CHMC: Cooling reduced by 63 kWh/year Heating increased by 0.6-1.7%, considered negligible Cost saving reduced by 40%	[28,30–32]	$2.16 USD (2015) 65 W; 1,200 h Usage assumed 3h/day	[28,30,31]
33	ENERGY STAR Light Bulbs (LED)	Incandescent	Commercial/Institutional	$51.95 USD (2015) 23 W; 50,000 h Usage assumed 8 h/day	[28,30–32]	$2.30 USD (2015) 100 W; 1,200 h Usage assumed 8 h/day	[28,30,33]
34	ENERGY STAR Light Bulbs (CFL)	Incandescent	Commercial/Institutional	$5.93 USD (2015) 26 W; 8,000 h Usage assumed 8 h/day Toronto values from CHMC: Cooling reduced by 19% (average of 15%–22%) Heating increased by 0.6%–1.7%, considered negligible Cost saving reduced by 40%	[28,30–32]	$2.30 USD (2015) 100 W; 1,200 h Usage assumed 8 h/day	[28,30,33]
35	ENERGYSTAR Air Conditioning	Standard Air Conditioning Unit	Residential (Low-Rise)	$1245 USD (2015) 2315 kWh/year 15 year lifetime	[24,34]	$850USD(2015) 2,850kWh/year 15 year lifetime	[24,34]
36	ENERGYSTAR HVAC	Standard HVAC Unit	Commercial/Institutional	$9617 USD (2015) 10,805 kWh/year 15 year lifetime	[24,35]	$10,257 USD (2015) 12,519 kWh/year 15 year lifetime	[24,35]

1. Incremental O&M costs for Photovoltaics and Wind technologies were used without calculation of the mitigation *vs.* reference because the figures were from a Toronto Case study so the approximation is valid; 2. If the difference between the lifetime of the Reference technology and mitigation measure is 5 years, it was taken to be equivalent in the calculations; 3. If not stated otherwise, costs are in Canadian Dollars; 4. 1 USD = 1.2 CDN.

Table S5. Cost-effectiveness and GHG abatement of mitigation measures in the building sector.

No.	Mitigation Measure	Cost-Effectiveness 2012 ($/tCO$_2$)	GHG Abatement Assumptions	References for Abatement Assumptions	GHG Abatement Assumptions in 2020	GHG Abatement in 2020 (tCO$_2$)	GHG Abatement Assumptions in 2050	GHG Abatement in 2050 (tCO$_2$)
1	Photovoltaics (Residential)	2384	100 systems installed 2008–2010; 50 systems annually	[36]	400 system implementations	6048	1900 system implementations	28,728
2	Photovoltaics (Commercial-Small Business)	1989	Estimated based on residential application; assuming 10 systems annually	[36]	80 system implementations	6624	380 system implementations	31,464
3	Photovoltaics (Commercial/Institutional)	2045	Estimated based on residential application; assuming 5 systems annually	[36]	40 system implementations	21,600	190 system implementations	102,600
4	Solar Air Heater (Residential) NG Home	−161	Estimated based on residential application; assuming 50 systems annually	[36]	400 system implementations	47,734	1900 system implementations	226,739
5	Solar Air Heater (Residential) E Home	−351	Estimated based on residential application; assuming 50 systems annually	[36]	400 system implementations	12,902	1,900 system implementations	61,286
6	Solar Air Heater (Commercial-Small Business) NG SB	−23	Estimated based on residential application; assuming 10 systems annually	[36]	80 system implementations	26,111	380 system implementations	124,028
7	Solar Air Heater (Commercial-Small Business) E SB	−448	Estimated based on residential application; assuming 10 systems annually	[36]	80 system implementations	25,805	380 system implementations	122,573
8	ENERGY STAR Natural Gas Furnace NG Home	−18	50 households went through the HEAT Program annually	[37]	400 households	4888	1900 households	23,217
9	Electric Heat Pump NG Home	−220	50 households went through the HEAT Program annually	[37]	400 households	31,860	1900 households	151,336
10	Solar Water Heater (Replacing Electric Storage Water Heater) (Residential) E Home	−158	100 systems installed 2008-2010; 50 systems annually	[36]	400 system implementations	6797	1900 system implementations	32,285

Table S5. *Cont.*

No.	Mitigation Measure	Cost-Effectiveness 2012 ($/tCO$_2$)	GHG Abatement Assumptions	References for Abatement Assumptions	GHG Abatement Assumptions in 2020	GHG Abatement in 2020 (tCO$_2$)	GHG Abatement Assumptions in 2050	GHG Abatement in 2050 (tCO$_2$)
11	Solar Water Heater (Replacing Natural Gas Storage Water Heater) (Residential) NG Home	−58	100 systems installed 2008-2010; 50 systems annually	[36]	400 system implementations	38,304	1900 system implementations	181,946
12	Solar Water Heater (Replacing Electric Storage Water Heater) (Commercial-Small Business) E SB	−452	Estimated based on residential application; assuming 10 systems annually	[36]	80 system implementations	5406	80 system implementations	23,967
13	Solar Water Heater (Replacing Natural Gas Storage Water Heater) (Commercial-Small Business) E SB	−57	Estimated based on residential application; assuming 10 systems annually	[36]	80 system implementations	31,102	80 system implementations	147,735
14	Solar Water Heater (Replacing Electric Storage Water Heater) (Commercial/Institutional) E C/I	−560	Estimated based on residential application; assuming 5 systems annually	[36]	40 system implementations	18,922	40 system implementations	89,878
15	Solar Water Heater (Replacing Natural Gas Storage Water Heater) (Commercial/Institutional) NG C/I	−63	Estimated based on residential application; assuming 5 systems annually	[36]	40 system implementations	64,796	40 system implementations	307,780
16	Wind (Residential)	1058	Estimated based on 10 installations in Toronto 2002–2011; assuming 1 annually	[38]	8 installations	118	38 installations	559

Table S5. *Cont.*

No.	Mitigation Measure	Cost-Effectiveness 2012 ($/tCO$_2$)	GHG Abatement Assumptions	References for Abatement Assumptions	GHG Abatement Assumptions in 2020	GHG Abatement in 2020 (tCO$_2$)	GHG Abatement Assumptions in 2050	GHG Abatement in 2050 (tCO$_2$)
17	Wind (Commercial - Small Business)	1805	Estimated based on 10 installations in Toronto 2002–2011; assuming 1 annually	[38]	8 installations	288	38 installations	1368
18	Wind (Commercial/ Institutional)	124	10 installations in Toronto 2002–2011; assuming 1 annually	[38]	8 installations	3120	38 installations	14,820
19	ENERGY STAR High Efficiency Electric Storage Water Heater E Home	−559	Electric water heaters are 40% of the market share (97% storage tanks; 3% tankless) Assumed 3% market penetration of ENERGY STAR products	[38]	Calculated from assumptions	4108	Calculated from assumptions	5154
20	ENERGY STAR High Efficiency Electric Storage Water Heater (Heat Pump) E Home	−396	Electric water heaters are 40% of the market share (97% storage tanks; 3% tankless) 1% market penetration in 2011 of ENERGY STAR products	[20,39]	Calculated from assumptions	584	Calculated from assumptions	733
21	ENERGY STAR Whole Home Gas Tankless Water Heater NG Home	−181	Gas water heaters are 53% of the market share (97% storage tanks; 3% tankless) Assumed 1% market penetration in 2011 of ENERGY STAR products	[20]	Calculated from assumptions	1897	Calculated from assumptions	2380
22	ENERGY STAR High-Efficiency Gas Storage Water Heater NG Home	−73	Gas water heaters are 53% of the market share (97% storage tanks; 3% tankless) 3% market penetration of ENERGY STAR products	[20,39]	Calculated from assumptions	42,943	Calculated from assumptions	53,875
23	ENERGY STAR High Efficiency Electric Water Heater (Heat Pump) NG Home	−63	Electric water heaters are 40% of the market share (97% storage tanks; 3% tankless) 1% market penetration in 2011 of ENERGY STAR products	[20,39]	Calculated from assumptions	4511	Calculated from assumptions	5659
24	ENERGY STAR Refrigerator	−658	56% market penetration in 2011 of ENERGY STAR products	[39]	Calculated from assumptions	232,225	Calculated from assumptions	291,343

Table S5. *Cont.*

No.	Mitigation Measure	Cost-Effectiveness 2012 ($/tCO$_2$)	GHG Abatement Assumptions	References for Abatement Assumptions	GHG Abatement Assumptions in 2020	GHG Abatement in 2020 (tCO$_2$)	GHG Abatement Assumptions in 2050	GHG Abatement in 2050 (tCO$_2$)
25	ENERGY STAR Clothes Dryer (Electric) E Home	257	63% of households have an electric clothes dryer Assumed 61% market penetration	[40]	Calculated from assumptions	203,547	Calculated from assumptions	255,364
26	ENERGY STAR Clothes Dryer (Gas) NG Home	186	15% of households have a gas clothes dryer Assumed 61% market penetration	[40]	Calculated from assumptions	98,857	Calculated from assumptions	124,023
27	ENERGY STAR Dishwasher	−9	Assumed 60% of households have a dishwasher 96% market penetration in 2011 of ENERGY STAR products	[39]	Calculated from assumptions	226,617	Calculated from assumptions	284,307
28	ENERGY STAR Clothes Washer	−566	Assumed 80% have a clothes washer 61% market penetration in 2011 of ENERGY STAR products	[39]	Calculated from assumptions	620,151	Calculated from assumptions	778,728
29	ENERGY STAR Light Bulbs (LED)	−433	70% of residential lighting is currently incandescent Market penetration of LED is 20% Assume 30 bulbs/household	[39,41]	Based on existing stock in 2012, 57,545 incandescent lightbulbs replaced annually for 8 years 460,360 LED lightbulbs	85,627	Based on existing stock in 2012, 57,545 incandescent lightbulbs replaced annually for 38 years 2,186,710 LED lightbulbs	406,728
30	ENERGY STAR Light Bulbs (CFL)	−607	70% of residential lighting is currently incandescent Market penetration of CFL is 76% Assume 30 bulbs/household	[39,41]	Based on existing stock in 2012, 218,671 incandescent lightbulbs replaced annually for 8 years 1,749,368 CFL lightbulbs	27,979	Based on existing stock in 2012, 218,671 incandescent lightbulbs replaced annually for 38 years 8,309,49 CFL lightbulbs	132,899
31	ENERGY STAR Light Bulbs (LED)	−433	70% of residential lighting is currently incandescent Market penetration of LED is 20%	[39,41]	24,634 lightbulbs replaced to LED (representing 20% of the market share) 197,072 lightbulbs	62,669	24,634 lightbulbs replaced to LED (representing 20% of the market share) 936,092 lightbulbs	297,677

Table S5. *Cont.*

No.	Mitigation Measure	Cost-Effectiveness 2012 ($/tCO$_2$)	GHG Abatement Assumptions	References for Abatement Assumptions	GHG Abatement Assumptions in 2020	GHG Abatement in 2020 (tCO$_2$)	GHG Abatement Assumptions in 2050	GHG Abatement in 2050 (tCO$_2$)
32	ENERGY STAR Light Bulbs (CFL)	−582	TCHC Case study shows18,722 CFL lightbulbs replacing incandescent lightbulbs in 15 MUR in 2011; and 74 MURs in 2012. 70% of residential lighting is currently incandescent Market penetration of CFL is 76%	[39,41,42]	Assumed 93,610 incandescent lightbulbs replaced with CFL annually for 8 years; 93,610 light bulbs annually (representing 76% of the market share) 748,880 lightbulbs	33,365	Assumed 93,610 incandescent lightbulbs replaced with CFL annually for 8 years; 93,610 light bulbs annually (representing 76% of the market share) 3,557,180 lightbulbs	158,485
33	ENERGY STAR Light Bulbs (LED)	−527	0.4lightbulbs/m^2 assumed 10% of commercial lighting is currently incandescent Market penetration of LED is 20%	[39,41]	Calculated from assumptions	428,316	Calculated from assumptions	847,292
34	ENERGY STAR Light Bulbs (CFL)	−460	Assuming 208 lightbulbs replaced in a 502 sq m commercial establishment based on a Toronto Hydro case study. Assuming 0.4 lightbulbs/m^2 10% of commercial lighting is currently incandescent Market penetration of CFL is 76%	[39,41,43.44]	Calculated from assumptions	306,080	Calculated from assumptions	605,485
35	ENERGYSTAR Air Conditioning	−134	50 households went through the HEAT Program annually; assuming a similar number for cooling initiatives	[37]	400 households	385	1,900 households	1,830
36	ENERGYSTAR HVAC	−387	50 households went through the HEAT Program annually; assuming a similar number for cooling initiatives		400 establishments	1234	1,900 establishments	5,862

Table S6. Economic costs and GHG emission inputs of mitigation measures in the transportation sector.

No.	Mitigation Measure	Reference Technology	Sub-Sector	Economic Cost Inputs and Assumptions of Mitigation Measure	References for Economic Costs	Economic Cost Inputs and Assumptions of Reference Technology	References for Economic Costs
1	Battery Electric Vehicle	Vehicle with Internal Combustion Engine	Passenger vehicle	$40,000 (2012) (Average vehicle) $217.50 (2012) O&M costs are assumed one third cheaper than ICT. 23 kWh battery (4–6 h charging) Electric range 122 km Annual distance travelled 15,000 km 15 year lifetime	[2,45]	$25,000 (2015) (Average vehicle) $652.50 (2012) (CAA 2012) (Average vehicle price) 9.5l/100km (2010 stock average for LDV) 2.8kg/l CO_2 intensity of fuel	[2,46,47]
2	Plug-in Hybrid Electric Vehicle	Vehicle with Internal Combustion Engine	Passenger vehicle	$40,000 (2012) (Price of average vehicle) $0.27 kWh/km (average) Fuel consumption Annual distance travelled 15,000 km Assuming 60% on electricity and 40% on gas 15 year lifetime	[2,45]	$25,000 (2015) (Average vehicle price) 9.5l/100 km (2010 stock average for LDV) 2.8kg/LCO_2 intensity of fuel	[2,47]
3	Diesel/Hybrid Bus	Diesel Bus	Bus	$734,000 (2008) 27/100 km Annual distance travelled 73,000 km 18 year lifetime	[2,47]	$500,000 (2008) 39l/100 km Annual distance travelled 73,000 km	[2,47]
4	Medium Duty Truck	Medium Duty Truck	Freight Truck	$43,120 (USD2015) 16l/100 km Assumed 146,000 km travelled per year 4 year lifetime	[2,49,50]	$38,120 (Assumed $5,000 (USD2014) less than new truck) 20l/100 km	[2]
5	Heavy Duty Truck	Heavy Duty Truck	Freight Truck	$84,600 (USD2015) 28.5l/100 km Assumed 160,000 km travelled per year 4 year lifetime	[2,49,50]	$74,600 (Assumed $10,000 (USD2014) less than new truck) 36l/100 km	[2]

1. If not stated otherwise, costs are in Canadian Dollars; 2. 1USD = 1.2CDN.

Table S7. Cost-effectiveness and GHG abatement of mitigation measures in the transportation sector.

No.	Mitigation Measure	Cost-Effectiveness 2012 ($/tCO$_2$)	GHG Abatement Assumptions	References for Abatement Assumptions	GHG Abatement Assumptions in 2020	GHG Abatement in 2020 (tCO$_2$e)	GHG Abatement Assumptions in 2050	GHG Abatement in 2050 (tCO$_2$)
1	Battery Electric Vehicle	111	119BEVs/year based on Plug "*n*" Drive Statistics 2011–2014	[45]	1248 vehicles	59,632	5928 vehicles	283,254
2	Plug-in Hybrid Electric Vehicle	283	98PHEVs/year based on Plug "*n*" Drive Statistics 2011–2014	[45]	488 vehicles	28,943	2318 vehicles	137,477
3	Diesel/Hybrid Bus	360	Based on 33% of 500 bus fleet is diesel/hybrid, and assumed in the time frame 2008-2015. 24 buses/year	[51]	192 buses	83,540	912 buses	396,813
4	Medium Duty Truck	−354	Assuming rate of greening is similar to City's green fleet plan of 130 vehicles/year total. Ratio of Medium:Heavy is 70: 30 assumed Assumed 39 per year	[52,53]	312 trucks	20,111	1482 trucks	95,529
5	Heavy Duty Truck	−354	Assuming rate of greening is similar to City's green fleet plan of 130 vehicles/year total. Ratio of Medium:Heavy is 70:30 assumed Assumed 91 per year	[52,53]	728 trucks	96,424	3458 trucks	458,016

Table S8. Economic costs and GHG emission inputs of mitigation measures in the waste sector.

No.	Mitigation Measure	Reference Technology	Sub-Sector	Economic Cost Inputs and Assumptions of Mitigation Measure	References for Economic Costs	Economic Cost Inputs and Assumptions of Reference Technology	References for Economic Costs
1	Diversion-LR	N/A	Residential	Assumed zero	-	N/A	-
2	Diversion-MUR	N/A	Residential	Assumed zero	-	N/A	-
3	Diversion–C/I	N/A	Commercial/Institutional	Assumed zero	-	N/A	-

Table S9. Cost-Effectiveness and GHG Abatement of Mitigation Measures in the Waste Sector.

No.	Mitigation Measure	Cost-Effectiveness 2012 ($/tCO$_2$)	GHG Abatement Assumptions	References for Abatement Assumptions	GHG Abatement Assumptions in 2020	GHG Abatement in 2020 (tCO$_2$)	GHG Abatement Assumptions in 2050	GHG Abatement in 2050 (tCO$_2$)
1	Diversion - SF	0	Applicable to low-rising housing in the residential building stock. 1% annual increase in diversion rate.	Abatement in target years obtained from METRO model	73% diversion	21,695	100% diversion	283,951
2	Diversion - MUR	0	Applicable to multi-unit residential housing in the residential building stock. 1.4% annual increase in diversion rate.	Abatement in target years obtained from METRO model	33% diversion	27,361	75% diversion	202,185
3	Diversion – C/I	0	Applicable to commercial/institutional establishments 1% annual increase in diversion rate.	Abatement in target years obtained from METRO model	22% diversion	108,626	52% diversion	801,759

References

1. OPA (Ontario Power Authority), Integrated Power System Plan. Exhibit G, Tab 2, Schedule 1. Ministry of Energy, Canada, 2008. Available online: http://www.ontarioenergyboard.ca/documents/cases/EB-2007-0707/exhibits_issues/exhibit_5_pollution_probe_20080115.pdf.pdf (accessed on 14 March 2016)
2. IPCC. Climate change 2014: Mitigation of climate change. In *Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E., Farahani, S., Kadner, K., Seyboth, A., Adler, I., Baum, S., Brunner, P., Eickemeier, B., *et al.*, Eds.; Cambridge University Press: Cambridge, UK; New York, NY, USA, 2014.
3. Achieving Balance: Ontario's Long-Term Energy Plan, Ontario; 2013. Available online: http://www.energy.gov.on.ca/en/files/2014/10/LTEP_2013_English_WEB.pdf (accessed on 14 March 2016)
4. Bristow, D. Buildings Scale Alternative Energy: A Comparative Analysis & Economic Model for the Ontario Case. Master's Thesis, University of Toronto, Toronto, ON, Canada, 2009.
5. SEIA (Solar Energy Industries Association), 2015. Available online: http://www.seia.org/policy/environment/pv-recycling (accessed on 14 March 2016).
6. Renewable Energy World, 2014. Available online: http://www.renewableenergyworld.com/rea/blog/post/print/2014/04/building-integrated-solar-air-heating-systems-proving-popular (accessed on 14 March 2016).
7. Furnace Prices. Canadian Furnace Prices. 2015. Available online: http://www.furnaceprices.ca/ (accessed on 14 March 2016).
8. ASHRAE Equipment Life Expectancy Chart. 2013. Available online: http://www.f22designs.com/cullum/wpcontent/uploads/2013/02/ASHRAE_Chart_HVAC_Life_Expectancy%201.pdf (accessed on 14 March 2016).
9. Toronto Hydro. Appliance Usage Chart. 2015. Available online: https://www.torontohydro.com/sites/electricsystem/residential/yourbilloverview/Pages/ApplianceChart.aspx (accessed on 14 March 2016).
10. Heat Pump Price Guides. Heat Pump Price Comparison Guides. 2014. Available online: http://www.heatpumppriceguides.com/ (accessed on 14 March 2016).
11. York Commercial Furnaces. 2015. Available online: http://www.york.com/residential/products/furnaces/commercial-gy8s-e-furnace.aspx (accessed on 14 March 2016).
12. Solar Consultants. Considerations in Choosing a Backup Water Heating System. 2009. Available online: http://www.solarconsultants.com/library/backup_wh_options.pdf (accessed on 14 March 2016).
13. Manitoba Hydro, 2015. https://www.hydro.mb.ca/your_home/solar_water_heating/collectors.shtml (accessed on 14 March 2016).
14. Global Energy Partners, 2005. Electric Tankless Water Heating: Competitive Assessment. With costing data from RS Means Buildings Construction Cost Data. Available online: http://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/ElectricTanklessCompetitiveAssessment.pdf (accessed on 14 March 2016).
15. Rheem, 2015. Available online: http://www.rheem.com/products/commercial/water_heating/commercial_gas/ (accessed on 14 March 2016).
16. Home Depot US. Residential Electric Water Heaters. 2015. Available online: http://www.homedepot.com/b/Plumbing-Water-Heaters-Residential-Electric/N-5yc1vZc1u1Z12le?NCNI-5# (accessed on 14 March 2016).
17. Home Depot US. Residential Gas Water Heaters. 2015. Available online: http://www.homedepot.com/b/Plumbing-Water-Heaters-Residential-Gas/N-5yc1vZc1tzZ12le?NCNI-5 (accessed on 14 March 2016).
18. Home Depot US. Commercial Gas Water Heaters. 2015. Available online: http://www.homedepot.com/b/Plumbing-Water-Heaters-Commercial-Commercial-Gas-Water-Heaters/N-5yc1vZc74l (accessed on 14 March 2016).
19. Imperial College, 2014. Available online: http://www3.imperial.ac.uk/newsandeventspggrp/imperialcollege/newssummary/news_20-2-2014-9-18-49 (accessed on 14 March 2016).
20. Energy Star Hot water use at home. Available online: https://www.energystar.gov/ia/new_homes/features/WaterHtrs_062906.pdf (accessed on 14 March 2016).
21. Lowe's. When to Replace a Water Heater. 2015. Available online: http://www.lowes.com/projects/repair-and-maintain/when-to-replace-a-water-heater/project (accessed on 14 March 2016).
22. Pro Water Heater Supply. Whole House Tankless. 2015. Available online: http://www.prowaterheatersupply.com/shop-by-category/bosch-whole-house-tankless-water-heaters.html?p=1 (accessed on 14 March 2016).

23. GE (General Electric). ENERGY STAR Appliances. 2015. Available online: http://www.geappliances.com/energy-star-appliances/ (accessed on 14 March 2016).
24. NRC (Natural Resources Canada). Look for ENERGY STAR. 2011. Available online: http://www.rncan.gc.ca/sites/oee.nrcan.gc.ca/files/files/pdf/residential/business/v6_eng.pdf (accessed on 14 March 2016).
25. Average Life Span of Homes, Appliances, and Mechanicals. 2015. Available online: http://www.atdhomeinspection.com/advice/average-product-life/ (accessed on 14 March 2016).
26. ENERGY STAR Market & Industry Scoping Report, Residential Clothes Dryers, November 2011. Available online: http://www.energystar.gov/ia/products/downloads/ENERGY_STAR_Scoping_Report_Residential_Clothes_Dryers.pdf (accessed on 14 March 2016).
27. Dryer Buying Guide. 2013. Available online: http://www.cnet.com/topics/dryers/buying-guide/ (accessed on 14 March 2016).
28. Earth Easy. LED Light Bulbs: Comparison Charts. 2015. Available online: http://eartheasy.com/live_led_bulbs_comparison.html (accessed on 14 March 2016).
29. Home Depot Canada. 12W LED. 2015. Available online: http://www.homedepot.ca/product/led-12w-a-line-daylight/826492 (accessed on 14 March 2016).
30. Home Depot US. 65W incandescent. 2015. Available online: http://www.homedepot.com/p/Philips-65-Watt-Incandescent-BR30-Flood-Light-Bulb-12-Pack-248872/100560688 (accessed on 14 March 2016).
31. Comparison Chart: LED Lights *vs.* Incandescent Light Bulbs *vs.* CFLs. 2015. Available online: http://www.designrecycleinc.com/led%20comp%20chart.html (accessed on 14 March 2016).
32. Research Highlight: Benchmarking Home Energy Savings from Energy-Efficient Lighting, Technical Series 08-101, January 2008. Available online: http://www.cmhc.ca/odpub/pdf/65830.pdf (accessed on 14 March 2016).
33. Home Depot US. 100W incandescent. 2015. Available online: http://www.homedepot.com/p/Philips-100-Watt-Incandescent-A21-250-Volt-Rough-Service-Frosted-Light-Bulb-60-Pack-275503-0/204148596 (accessed on 30 Aug 2015).
34. Sachs, H.; Nadel, S.; Amann, J.; Tuazon, M.; Mendelsohn, E.; Rainer, L.; Todesco, G.; Shipley, D.; Adelaar, M. Emerging Energy-Saving Technologies and Practices for the Building Sector as of 2004. American Council for and Energy Efficient Economy A042. Available online: http://www.greenbiz.com/sites/default/files/document/CustomO16C45F60305.pdf (accessed on 14 March 2016).
35. Global Industrial. Commercial Air Conditioners. 2015. Available online: http://www.globalindustrial.ca/p/hvac/air-conditioning/air-conditioners-commercial/ceiling-air-conditioner-5-ton-42000-btu-water-cooled?infoParam.campaignId=T9F&gclid=Cj0KEQjw9JuuBRC2xPG59dbzkpIBEiQAzv4-G__ZhsEKjPMrASNQBRbRL0ujvEZ8dJp2eyUrvwON0G8aAjQl8P8HAQ (accessed on 14 March 2016).
36. TAF (Toronto Atmospheric Fund). Solar Neighbourhoods Pilot Project Findings. 2010. Available online: http://www.solarneighbourhoods.ca/wrap_report.pdf (accessed on 14 March 2016).
37. Furnace Price Guides. Compare Gas Furnace Prices. 2015. Available online: http://www.furnacepriceguides.com/gas-furnace/ (accessed on 14 March 2016).
38. Wind Power. 7000 Large Onshore Wind Turbines in Ontario. 2011. Available online: https://windpowergrab.wordpress.com/ (accessed on 14 March 2016).
39. Energy Star Unit Shipment and Market Penetration Report Calendar Year 2011 Summary. 2012. Available online: http://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2011_USD_Summary_Report.pdf?f975-6ad4 (accessed on 14 March 2016).
40. ENERGY STAR Qualified Products. 2010. Available online: http://www.hotwater.com/resources/energy-star-qualified-products/ (accessed on 30 Aug 2015).
41. Sugar, L.; Kennedy, C. A low carbon infrastructure plan for Toronto, Canada. *Can. J. Civil Eng.* **2013**, *40*, 86–96.
42. Toronto Hydro. Toronto Community Housing's energy saving investment pays in two ways. 2012. Available online: http://www.torontohydro.com/sites/electricsystem/electricityconservation/businessconservation/Documents/Toronto%20Community%20Housing%20Corporation.pdf (accessed on 14 March 2016).
43. Toronto Hydro. Sunrise Records Lighting Retrofit Cuts Costs, Brings New Life to Store. 2012. Available online: http://www.torontohydro.com/sites/electricsystem/electricityconservation/businessconservation/Documents/SunriseRecords%20CaseStudy_FINAL.pdf (accessed on 14 March 2016).
44. ESP (ESP Lighting). CFL Light bulbs. 2015. Available online: http://www.esplighting.com/fluorescent-light-bulbs--cfls-.html (accessed on 30 August 2015).

45. Plug'n Drive. Electric Vehicles. 2015. Available online: https://www.plugndrive.ca/electric-cars-available-in-canada?page=1 (accessed on 30 Aug 2015).
46. CAA (Canadian Automobile Association). Driving Costs: Beyond the Price Tag Understanding Your Vehicle's Expenses. 2012. Available online: https://caa.ca/docs/eng/CAA_Driving_Costs_English.pdf (accessed on 14 March 2016).
47. City of Toronto. Transportation Options. 2015. Available online: http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=d4c1ae0b7e612310VgnVCM1000003dd60f89RCRD&vgnextchannel=4a27ba2ae8b1e310VgnVCM10000071d60f89RCRD (accessed on 14 March 2016).
48. Effective Fuel Systems. Fuel Enhancement Technologies. 2008. Available online: http://www.effectivefuel.ca/techpage3.html (accessed on 14 March 2016).
49. Centre for Climate and Energy Solutions. Medium and Heavy Duty Vehicles. 2015. Available online: http://www.c2es.org/technology/Medium-and-Heavy-DutyVehicles (accessed on 14 March 2016).
50. NRC (Natural Resources Canada). Fuel Efficiency Benchmarking in Canada's Trucking Industry. 2015. Available online: http://www.nrcan.gc.ca/energy/efficiency/transportation/commercial-vehicles/reports/7607 (accessed on 14 March 2016).
51. Transport Canada. Urban Transportation Showcase Program. Case Studies in Sustainable Transportation. Case Study No. 71. 2009. Available online: http://www.tc.gc.ca/media/documents/programs/cs71e-hybridbuses.pdf (accessed on 14 March 2016).
52. Toronto Fleet Services. *Green Fleet Plan 2008–2011*; City of Toronto, Toronto, 2008. Available online: http://www.toronto.ca/legdocs/mmis/2008/gm/bgrd/backgroundfile-10521.pdf (accessed on 14 March 2016).
53. *City of Toronto Energy and Emissions Inventory and Mapping Report, Draft*; Canadian Urban Institute & Halsall Associates: Toronto, ON, Canada 2013.