Blue Box Diversion in Ontario:

A Cost/Benefit Analysis of Recycling Targets

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Executive Summary

The study highlights the costs and environmental impacts of different scenarios for achieving a 60% recycling rate of household generated printed materials and packaging recycled through Ontario's Blue Box program by 2008.

MacViro Consultants Inc. and Stewardship Ontario supplied the baseline data for 2003 and the 2008 generation projections for packaging and printed materials as well as the costs for recycling and managing remaining packaging and printed material residues.

The IWM computer model, supported by EPIC/CSR and Environment Canada and NRCan, was used to objectively measure the environmental impacts of different recycling scenarios and options for managing the residues remaining.

Scenarios were developed that examined a 60% 'overall' recycling rate for printed materials and packaging versus a 60% recycling rate for 'each material category' of packaging and printed materials. These scenarios also examined directing the residues (i.e. uncaptured Blue Box printed materials and packaging) to landfill, EFW and high efficiency EFW.

By using the IWM computer model to analyse the data and projected volumes, stakeholders can obtain a clear picture of the cost and environmental benefits of different recycling strategies.

The results and conclusions of this study are summarized below.

Cost and Targets

If all packaging materials generated in Ontario's households were recycled at 60%, this would drive Blue Box costs significantly upwards with marginal environmental benefits.

1. A 60% recycling rate on all household packaging materials will cost an estimated $383 million compared to $227 million for a 60% overall recycling rate (with residues landfilled in both cases).
2. This is an additional cost of $156 million if recycling rates of 60% are required on all packaging materials.
3. This additional cost would not justify the environmental benefits achieved. The 60% recycling rate on all packaging materials achieves similar reductions in NOx, PM and VOCs and only slightly more energy and GHG reductions than achieved through a 60% overall recycling rate (see Figures 1, 2 and 3)
4. In fact, a 60% recycling rate on all packaging materials would result in 23% more energy savings and only reduce GHGs by a further 266,000 tonnes about 0.1% of the 240 million GHG reductions required for Canada to meet its Kyoto requirements, but the estimated additional cost for the Blue Box program would be 69% higher or $156 million more. This is a significantly high incremental increase in cost to achieve marginal added environmental benefit.

5. By contrast, a 10% improvement in automotive fuel efficiency (litres/100kms) in Ontario's 6.95 million vehicles would result in a reduction of around 5.3 million tonnes of GHGs or 20 times more GHG reductions.

Integrated Waste Management

The analysis strongly suggests that if all residues were used to produce energy instead of being landfilled (i.e. uncaptured Blue Box printed materials and packaging), this would be more eco-efficient.

1. A 60% overall recycling rate for printed materials and packaging (with residues to EFW operating at 20% efficiency) costs $207 million compared to $383 million if all packaging materials are recycled at 60% (with residues to landfill).
2. This is $176 million less compared to a 60% recycling rate on all packaging materials (with residues to landfill).
3. Furthermore, the 60% overall recycling rate of printed materials and packaging (with residues to EFW) would provide the same energy savings benefit for almost half the price of recycling packaging materials all at 60% (with residues to landfill).
4. The cost can be further reduced using high efficiency energy recovery as practiced in Scandinavia. Directing the residues to a high efficiency EFW facility (50% efficiency) saves even more energy (117%) compared to recycling packaging materials all at 60% (with residues sent to landfill). This is achieved at approximately a quarter of the cost of recycling packaging materials all at 60%.
5. A 60% recycling rate on all packaging materials would only reduce GHGs by a further 142,000 tonnes compared to a 60% overall recycling rate (with residues to high efficiency EFW), about 0.6% of the 240 million GHG reductions required for Canada to meet its Kyoto requirements but the estimated cost for the Blue Box program would be an additional $277 million more or 72% higher per year. This is a significantly high incremental cost of $1950/tonne compared to a sale price for GHG credits of $5.14/tonne.

1.0 Introduction

New data collection methods and analytical tools have recently ushered in a new era in Ontario with respect to waste management and the diversion of waste from landfill via recycling and other strategies. It's now possible, for the first time, to objectively measure and evaluate the performance of the overall system both in terms of economic and environmental impacts, and compare the benefits of different waste diversion approaches.

All stakeholders interested in waste diversion – including environmentalists, policymakers, business people, waste management professionals, and concerned citizens – can benefit from understanding this new objective information and using it to evaluate the role of different components (e.g., recycling, composting, thermal treatment, landfill, etc.) in the system's eco-efficiency.

The purpose of this study is to provide information on the eco-efficiency (defined as achieving parallel ecological and economic gains, without sacrificing one for the other) of different diversion scenarios for Ontario's Blue Box program for printed materials and packaging.

For this purpose, the IWM computer model supported by EPIC/CSR, Environment Canada and National Resources Canada was used to objectively measure the environmental impacts of different recycling strategies and management options for residues.

The study drew upon estimates of Dan Lantz of MacViro Consultants and Stewardship Ontario for 2003 baseline data and projections of volumes and recovery rates for packaging and printed materials as well as for costs of recycling and the management of residues.

These make a powerful combination. By using the IWM computer model to analyze the robust Stewardship Ontario data and projections, stakeholders can obtain a clear picture of the cost and environmental benefits of different recycling scenarios.

2.0 Scenarios

In order to accomplish this, it made sense to investigate six scenarios, starting with the "ground truth" of the most recent year for which hard data is available, followed by different projections and options. The scenarios are:

Scenario One: ***2003 Baseline***

Actual 2003 data supplied by Stewardship Ontario. This is the measurement of Blue Box printed materials and packaging recycled and the residues managed.

Scenario Two: ***60% Overall - Landfill***

We project out to year 2008 and assume an overall recycling rate of 60% for printed materials and packaging using the *least cost per tonne*[1] approach (residues are landfilled).

Scenario Three: ***60% Each Material - Landfill***

We project out to year 2008 and assume a 60% recycling rate for each category of printed materials and packaging (with residues landfilled).

Scenario Four: ***60% Overall - EFW***

This is the same as Scenario Two, except instead of landfilling the residues; we utilize them in a thermal process to generate electricity (at an efficiency of 20%). We assume the electricity displaces energy from the Ontario grid (currently supplied by a mix of nuclear, hydroelectric and thermal firing).

Scenario Five: ***60% Each Material - EFW***

This is the same as Scenario Three, with the residues used to generate electricity at an efficiency of 20% rather than landfilled.

Scenario Six: ***60% Overall – High Efficiency EFW***

This is the same as Scenario Two, but now the residues are used in an energy-recovery system that's 50% efficient (not just 20%). The higher efficiency is achieved by cogeneration (i.e., electricity is generated and residual heat is captured from turbines to produce low-pressure steam or hot water for further applications.)

* **Note**: *The generation and recovery of each material in units of tonnes was supplied by D. Lantz of Macviro Consultants.*

[1] Least cost per tonne is defined as the focus on primarily recycling materials with the least impact on system cost and focusing less on materials with higher costs to achieve an overall recycling rate of at least 60%

3.0 Generation and Recovery of Household Printed Materials and Packaging

The generation, recovery and residue remaining for disposal for the years 2003 and 2008 are shown in Table 1 below. (For convenience, detailed information on each material classification is shown in the attached Excel spreadsheet.)

Table 1 Generation and Recovery of Household Printed Materials and Packaging (tonnes)

Year	Generation	Recovery	Residue
2003 actual	1,470,000	779,844	690,156
2008 60% recovery	1,564,180	939,061	625,119

4.0 Costs

The full cost of dealing with the volume of waste was calculated for each of the six scenarios. Full cost is made up of a number of components:

1 The net cost of *collecting and processing printed materials and packaging* at a materials recovery facility (MRF). (Net cost is gross cost of collection and MRF processing, less the revenue received from the sale of recyclable materials.)

2 The cost of *residue collection*. "Residues" are the quantity of uncaptured printed materials and packaging that remain in the waste stream.

3 The cost of putting the residues into a *landfill* or processing them through an *energy-from-waste (EFW) facility.*

4 In the cases where residues were processed through an EFW facility, credits were applied for the *energy sold* and for the recovery and sale of *metals* removed from the bottom ash. A charge applies for the landfilling of the remaining bottom ash.

The net cost to collect and process each material was supplied by Stewardship Ontario for the year 2003. (For convenience, the data are shown in the Appendices.) To properly model the cost of the scenarios, further reasonable assumptions were made.

We assumed:

1. *Residue collection* costs of $50 per tonne. (Our reference was Halton Region.)
2. *Landfill costs* for residues of $50 per tonne. (Reference Halton Region.)
3. *Tipping fee* for materials sent to an *EFW facility* of $129 per tonne. (Reference Peel Region.)
4. Landfilling *bottom ash* from the EFW facility at a cost of $50 per tonne.

5. The *metals* in the residues captured from the EFW facility are sold at the prevailing market price per tonne of $42.80 (steel) and $1,435.39 (aluminum).

6. *Energy* from the EFW plant is sold to the grid for 8 cents per kilowatt hour[1].

7. *Inflation*: Waste management costs and material revenues escalate 2% annually from 2003 to 2008.

A summary of the full cost to operate the waste management system for each of the scenarios is illustrated in Table 2. (The detailed costs for each scenario are included in Appendix)

Table 2 Full Cost to Manage Printed Material and Packaging

Scenario	Full Cost to Manage	Cost per tonne to Manage
ONE: Actual 2003 recovery.	$187,023,422	$127.23
TWO: 2008, 60% overall, residue to landfill.	$227,069,518	$145.17
THREE: 2008, 60% each material, residue to landfill.	$383,478,526	$245.16
FOUR: Same as Scenario 2 with residue to EFW and energy efficiency of 20%.	$207,477,801	$132.64
FIVE: Same as Scenario 3 with residue to EFW and energy efficiency of 20%.	$375,295,007	$239.93
SIX: Same as Scenario 2 with residue to EFW and energy efficiency of 50%.	$106,197,801	$67.89

[1] We have assumed that energy will sell at a value somewhere between current prices inflated to 2008 and the value of green energy in 2008.

5.0 Environmental Burdens

The ISWM model permits the user to consider many environmental burdens associated with the activity of waste management. Let's consider just two in this analysis: energy savings and reductions in greenhouse gas emissions. (We also briefly consider the precursors of smog and dioxin formation.)

5.1 Energy Savings

Recycling saves energy primarily by displacing the use of virgin materials. We can assume that a given quantity of materials that are recycled, then used, replace a like quantity of virgin materials and save the energy associated with the production of the virgin material. The ISWM model accounts for the energy used to collect and reprocess recycled materials. It also accounts for losses of materials that occur at the various stages of reprocessing. Energy is also expended in dealing with the landfilling of residuals (quantity generated minus quantity recovered).

In Scenarios Four, Five and Six the residuals are directed to an EFW plant such as Algonquin Power in Peel Region. The residuals generate electrical power that we assume is transferred to the Ontario power grid where it replaces power from other sources (coal-fired thermal, hydroelectric and nuclear).

The efficiency of EFW plants like Algonquin Power in converting power to electricity is typically 20 per cent. Modern co-generation techniques such as those practiced in Scandinavian EFW plants routinely achieve efficiencies in excess of 50%. In Scenario Six this 50% conversion efficiency was assumed.

5.2 Reductions in Greenhouse Gas Emissions

Recycling reduces greenhouse gases, again primarily through the displacement of virgin materials. Greenhouse gases are also reduced because materials are diverted from landfill some of which (e.g., paper) would degrade anaerobically and produce methane, which has 21 times the greenhouse gas potential of carbon dioxide. The model also tracks emissions of the oxides of nitrogen (NO_x) from the production of virgin and recycled materials, as well as from transportation (truck traffic) and any other combustion process. The greenhouse gas potential of NO_x is 310 times that of CO_2. Greenhouse gases are reported as tonnes of "carbon dioxide equivalents" (CO_2 equivalents), a unit that takes into account the global warming potential of various gases and converts them into tonnes of CO_2.

The ISWM model accounts for the emissions from collecting and processing recyclables and subtracts them from the credits. In Scenarios Four, Five and Six, any CO_2 produced by the burning of materials derived from fossil fuels such as plastics is counted as an emission. By international convention, CO_2 that results from the combustion of materials derived from biomass such as paper is *not* counted (as it's assumed to be part of the natural carbon cycle).

6.0 Results

All the scenarios include a significant amount of recycling. Naturally, therefore, each scenario offers energy savings. But the cost to implement each scenario differs substantially. Scenario Three (60% recycling of all material categories) costs the most. In fact, it costs 69% more than that of Scenario Two (60% diversion using *least cost per tonne*).

Table 3 lists the results. They are also illustrated graphically in Figure 1.

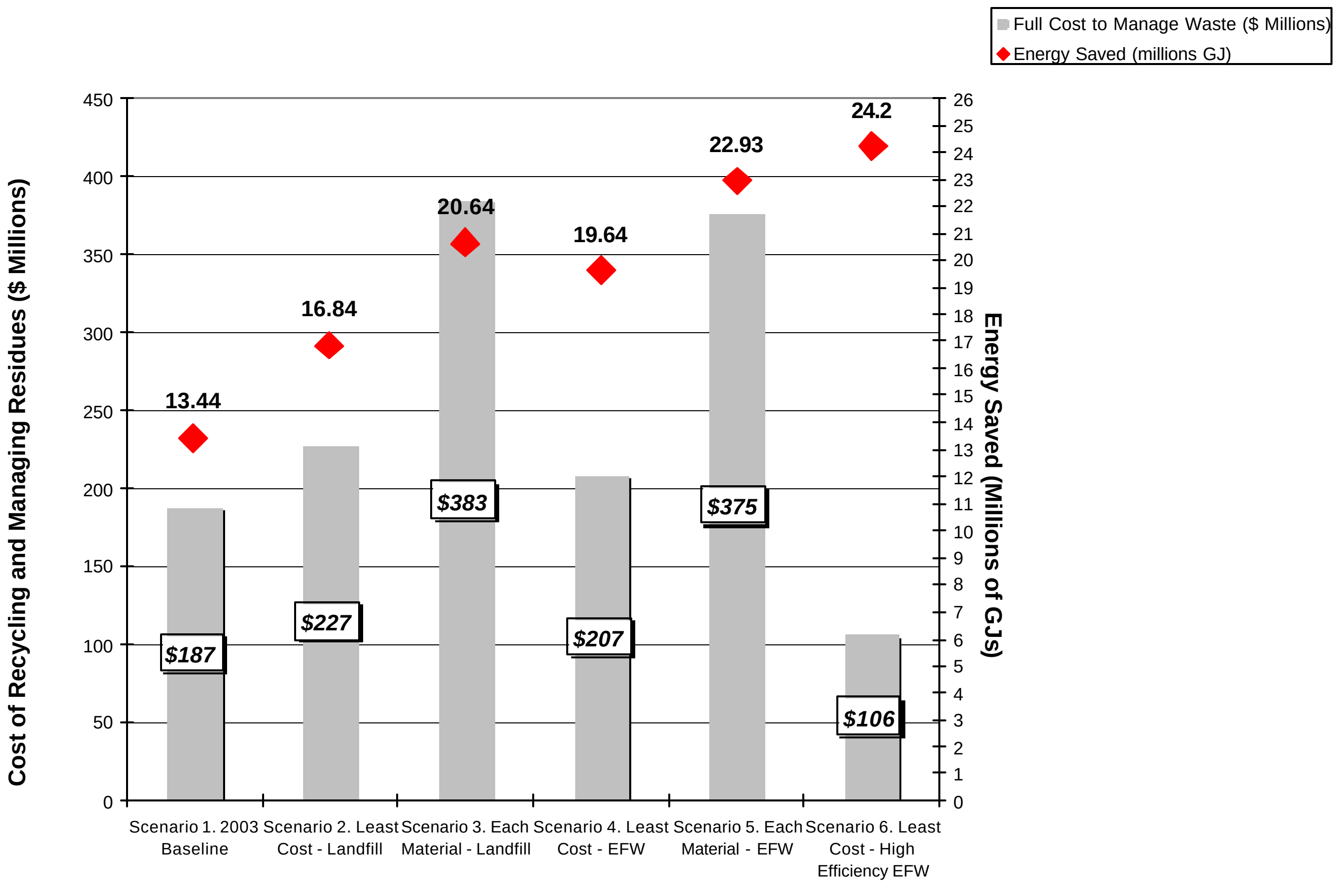
(**<u>Note</u>**: The model calculates energy in the metric unit gigajoules (GJ). One barrel of crude oil is equivalent to 5.75 GJ. We use this unit since it's an absolute measure of energy that includes the energy used to manufacture, transport or recycle materials and waste, and the electrical energy generated in some of the scenarios.)

6.1 Energy Savings

Table 3 Energy Savings and Cost

Scenario	Energy Saved (millions GJ)	Full Cost to Manage Waste ($ Millions)	Cost per GJ of Energy Saved ($)
ONE: Actual 2003 recovery.	13.44	187.02	13.92
TWO: 2008, 60%overall, residue to landfill.	16.84	227.07	13.48
THREE: 2008, 60% each material, residue to landfill.	20.64	383.48	18.58
FOUR: Same as Scenario 2 with residue to EFW and energy efficiency of 20%.	19.64	207.48	10.56
FIVE: Same as Scenario 3 with residue to EFW and energy efficiency of 20%.	22.93	375.30	16.37
SIX: Same as Scenario 2 with residue to EFW and energy efficiency of 50%.	24.20	106.20	4.39

Figure 1 Energy Saved Compared to the Costs of the Six Scenarios



6.2 Greenhouse Gas Reductions

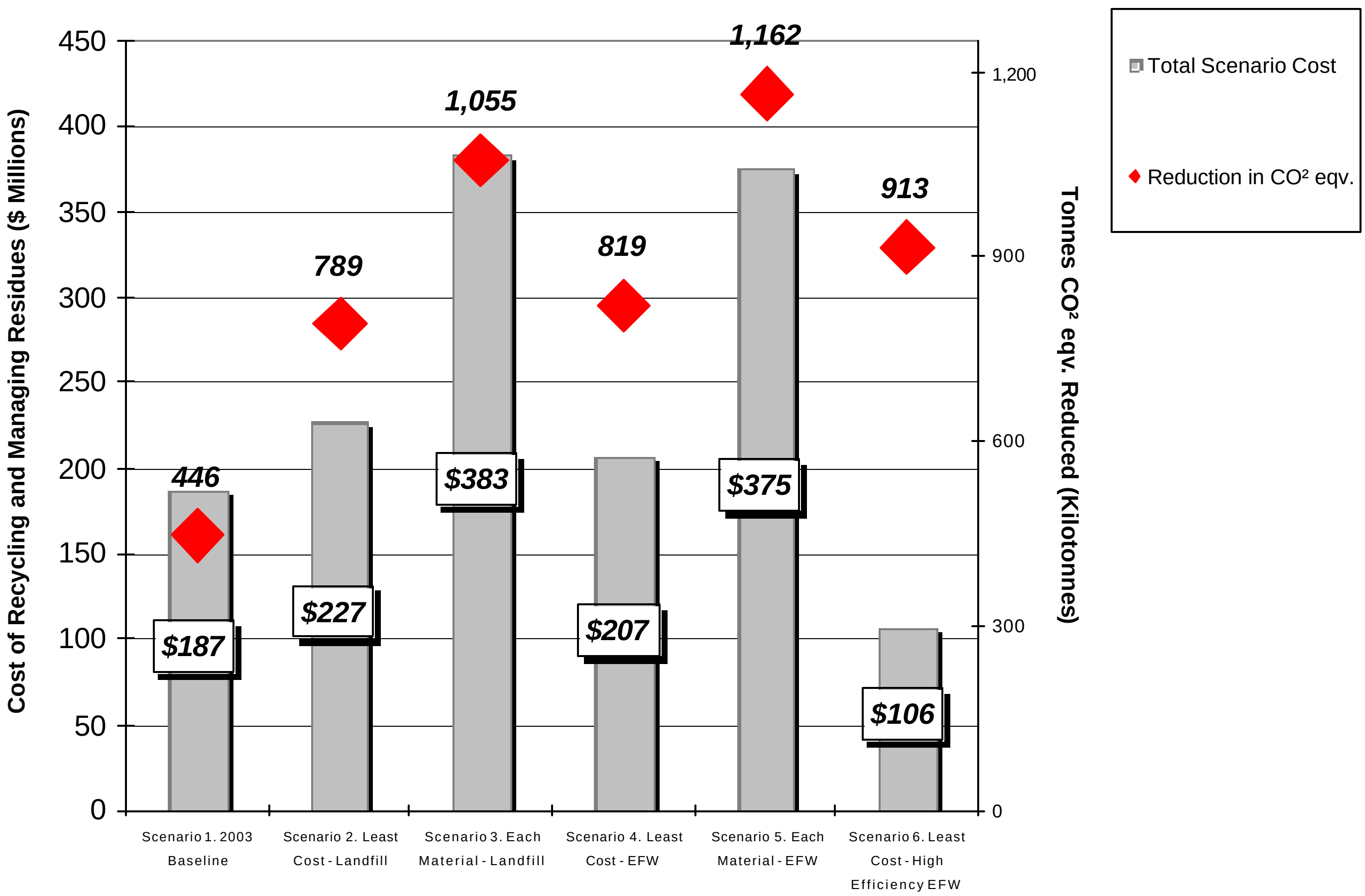
Every scenario affords a net reduction in greenhouse gas emissions, albeit at different costs. The results are exhibited in Table 4 and shown graphically in Figure 2.

Table 4 Greenhouse Gas Reductions

Scenario	Greenhouse Gas Reductions (tonnes CO_2 eqv.)	Full Cost to Manage Printed Materials & Packaging ($ millions)	Cost of Greenhouse Gas Reduction ($/tonne)
ONE: Actual 2003 recovery.	445,542	187.02	419.76
TWO: 2008, 60% overall, residue to landfill.	789,070	227.07	287.77
THREE: 2008, 60% each material, residue to landfill.	1,055,089	383.48	363.46
FOUR: Scenario 2, residue to EFW.	818,979	207.48	253.34
FIVE: Scenario 3, residue to EFW.	1,162,018	375.30	322.97
SIX: Scenario 2, residue to high efficiency EFW.	913,319	106.20	116.28

Note: As previously noted, although the quantities of residue going to EFW in Scenarios Four and Five are the same the composition of the residues are different. The residue of Scenario Five contains more materials derived from biomass e.g., paper than the residue of Scenario Four. The CO_2 emissions from the combustion of such materials are not counted and subtracted from the greenhouse gas emission credits that result from recycling and the displacement of other forms of power generation.

Figure 2 Greenhouse Gas Reductions Compared to the Cost of the Six Scenarios



Note: The cost per tonne of greenhouse gas reduction ranges from $116.28 to $419.76. This is very high compared to the value of recent trades of greenhouse gas credits. For instance, TransAlta Corp. recently purchased 1.75 million credits at a price of $5.14 each. (Source: *Globe and Mail*, 25 August 2004.)

6.3 Smog Precursors

SMOG: The oxides of nitrogen (NO_x), volatile organic chemicals (VOC) and particulate matter (PM) react with ultraviolet light to produce what is commonly called "smog" – a health risk especially for the young and the elderly. Summer smog in the Windsor to Quebec corridor is of particular concern. Through truck traffic, landfill operations (e.g., dust, VOC emissions) and combustion, waste management practices produce smog precursors. The ISWM model measures the production of smog precursors and where appropriate applies credits against production for certain activities (such as a reduction in vehicle traffic or, particularly, for recycling). Table 5 and Figure 3 summarize the reductions in smog precursors for the scenarios.

Although dioxins are not addressed in this study, in a report prepared for Environment Canada, Chandler and Associates have stated that the emissions of dioxins and furans to the atmosphere from controlled municipal solid waste (MSW) incinerators operating in Canada will be less than 0.2 grams TEQ/year in 2003.

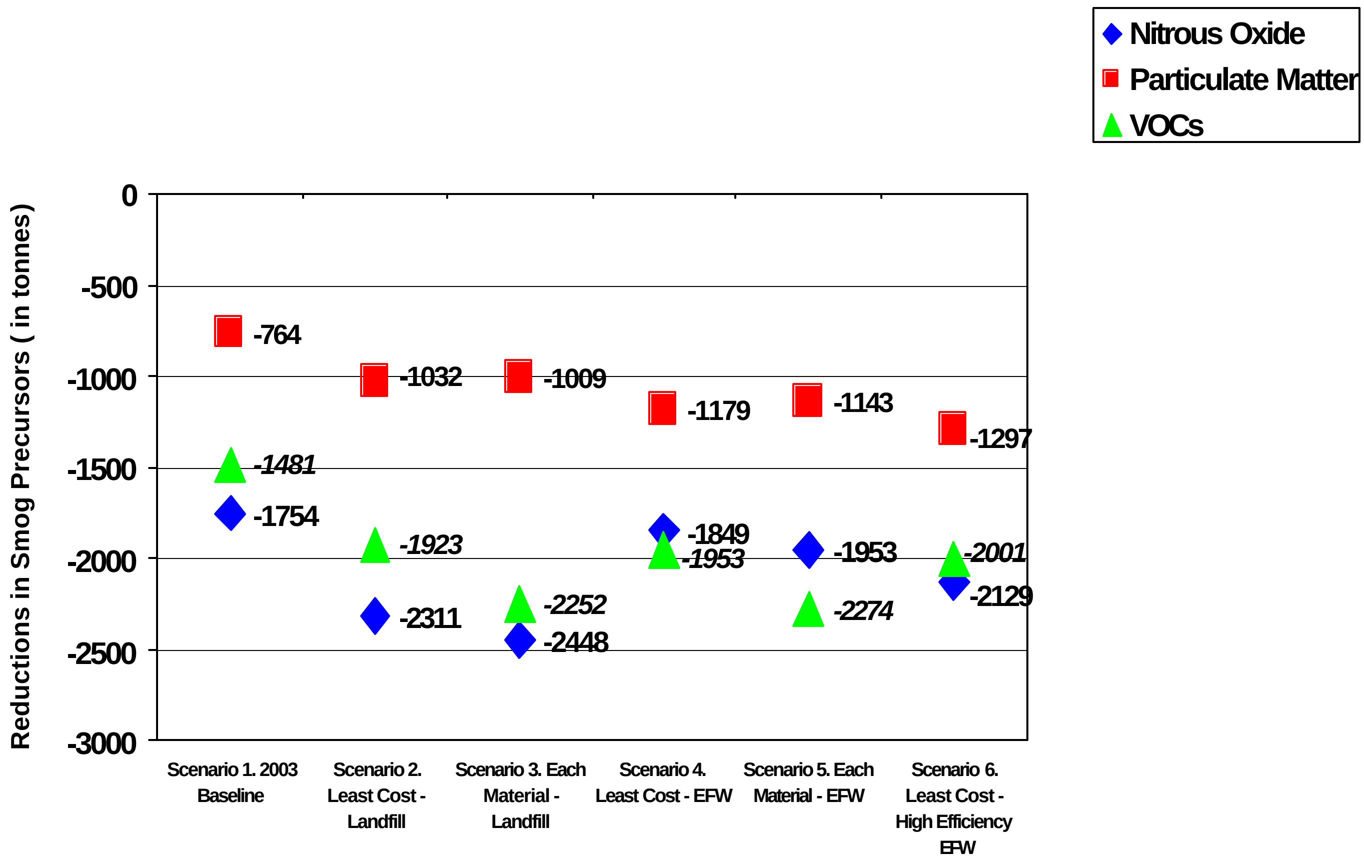
Table 5 Reductions in Smog Precursors (tonnes)

Scenario	NO_x	Particulate Matter	VOCs
ONE: Actual 2003 recovery.	1,754	764	1,481
TWO: 2008, 60% overall, residue landfilled.	2,311	1,032	1,923
THREE: 2008, 60% each material, residue to landfill.	2,448	1,009	2,252
FOUR: Scenario 2, residue to EFW.	1,849	1,179	1,953
FIVE: Scenario 3, residue to EFW.	1,953	1,143	2,274
SIX: Scenario 2, residue to high efficiency EFW.	2,129	1,297	2,001

Note: The NO_x reductions for Scenarios Four, Five and Six are all less than the 2008 scenarios in which residues are landfilled. This is due to the fact that all combustion processes utilizing air emit oxides of Nitrogen.

All of the scenarios investigated achieve comparable reductions in NOx, particulate matter and VOCs.

Figure 3 Reductions in Smog Precursors



7.0 Conclusions

The results and conclusions of this study are summarized below.

Cost and Targets

If all packaging materials generated in Ontario's households were recycled at 60%, this would drive Blue Box costs significantly upwards with marginal environmental benefits.

1. A 60% recycling rate on all household packaging materials will cost an estimated $383 million compared to $227 million for a 60% overall recycling rate (with residues landfilled in both cases).
2. This is an additional cost of $156 million if recycling rates of 60% are required on all packaging materials.
3. This additional cost would not justify the environmental benefits achieved. The 60% recycling rate on all packaging materials achieves similar reductions in NOx, PM and VOCs and only slightly more energy and GHG reductions than achieved through a 60% overall recycling rate. (Figures 1, 2 and 3.)
4. In fact, a 60% recycling rate on all packaging materials would result in 23% more energy savings and only reduce GHGs by a further 266,000 tonnes about 0.1% of the 240 million GHG reductions required for Canada to meet its Kyoto requirements, but the estimated additional cost for the Blue Box program would be 69% higher or $156 million more. This is a significantly high incremental increase in cost to achieve marginal additional environmental benefit.
5. In contrast, a 10% improvement in automotive fuel efficiency (litres/100kms) in Ontario's 6.95 million vehicles would result in a reduction of around 5.3 million tonnes of GHGs or 20 times more GHG reductions.

Integrated Waste Management

The analysis strongly suggests that if all residues were used to produce energy instead of being landfilled ((i.e. uncaptured Blue Box printed materials and packaging), this would be more eco-efficient.

6. A 60% overall recycling rate for printed materials and packaging (with residues to EFW operating at 20% efficiency) costs $207 million compared to $383 million if all packaging materials are recycled at 60% (with residues to landfill).
7. This is $176 million less compared to a 60% recycling rate on all packaging materials (with residues to landfill).

8. Furthermore, the 60% overall recycling rate of printed materials and packaging (with residues to EFW) would provide the same energy savings benefit for almost half the price of recycling packaging materials all at 60% (with residues to landfill).

9. The cost can be further reduced using high efficiency energy recovery as practiced in Scandinavia. Directing the residues to a high efficiency EFW facility (50% efficiency) saves even more energy (117%) compared to recycling packaging materials all at 60% (with residues sent to landfill). This is achieved at approximately a quarter of the cost of recycling packaging materials all at 60%.

10. A 60% recycling rate on all packaging materials would only reduce GHGs by a further 142,000 tonnes compared to a 60% overall recycling rate (with residues to high efficiency EFW), about 0.6% of the 240 million GHG reductions required for Canada to meet its Kyoto requirements but the estimated cost for the Blue Box program would be an additional $277 million more or 72% higher per year. This is a significantly high incremental cost of $1950/tonne compared to a sale price for GHG credits of $5.14/tonne.

Appendix A: Full Cost Summary for Scenario One

Generation 2003	Recovered 2003	Commodity	Net Cost of Municipal Recycling[1]	Cost to Collect Residue* $50/t[2]	Cost to Landfill Residue* $50/t[3]	Total Cost Recycling and Landfill
635,200	430,614	Printed Paper	$14,114,418	$10,229,300	$10,229,300	$32,903,618
328,100	156,902	Paper Packaging	$54,270,873	$8,559,900	$8,559,900	$72,011,673
219,000	35,382	Plastic Packaging	$30,762,193	$9,180,900	$9,180,900	$41,658,943
66,900	32,583	Steel Packaging	$7,280,965	$1,715,850	$1,715,850	$9,796,165
26,100	10,113	Aluminum Packaging	-$6,305,968	$799,350	$799,350	-$1,484,068
194,700	114,249	Glass Packaging	$17,885,241	$4,022,550	$4,022,550	$56,415,641
1,470,000	779,843	**Total**	**$118,007,722**	**$34,507,850**	$34,507,850	**$187,023,422**
		Total Net Cost				**$187,023,422**
		Net Cost per tonne				***$127.23***

[1] Stewardship Ontario, data 3, Nov. 04
[2] Reference Halton Region, 2004
[3] Reference Halton Region, 2004

* Residues are defined as the quantity of uncaptured printed materials and packaging that remain in the waste stream.

Appendix B: Full Cost Summary for Scenario Two and Scenario Four

			Scenario Two				Scenario Four		
Generation 2008	**Recovered 2008**	**Commodity**	**Net Cost of Municipal Recycling**	**Cost to Collect Residue $55/t[1]**	**Cost to Landfill Residue $55/t[1]**	**Total Cost Recycling & Landfill**	**Cost to Collect Residue $55/t[1]**	**EFW Tipping Fee $142/t[2]**	**Total Cost Recycling & EFW**
675,900	486,324	Printed Paper	$17,459,884	$10,426,680	$10,426,680	$36,009,624	$10,426,680	$26,919,792	54,806,356
349,120	201,428	Paper Packaging	$77,688,665	$8,123,060	$8,123,060	$96,350,055	$8,123,060	$20,972,264	106,783,989
233,030	41,424	Plastic Packaging	$39,531,406	$10,538,330	$10,538,330	$51,439,786	$10,538,330	$27,208,052	77,277,788
71,190	46,280	Steel Packaging	$11,417,975	$1,370,050	$1,370,050	$13,293,090	$1,370,050	$3,537,220	16,325,245
27,770	18,587	Aluminum Packaging	-$12,795,719	$505,065	$505,065	-$8,872,349	$505,065	$1,303,986	-10,986,668
207,170	145,019	Glass Packaging	$25,004,327	$3,418,305	$3,418,305	$62,804,122	$3,418,305	$8,825,442	37,248,074
1,564,180	939,062	**Total**	**$158,306,538**	**$34,381,490**	**$34,381,490**	**$227,069,518**	**$34,381,490**	**$88,766,756**	**281,454,784**
		Cost to landfill Bottom Ash[3]							7,212,450
		Credit Steel from EFW[4]							1,345,586
		Credit Al. from EFW[4]							17,603,847
		Credit Electr. from EFW[5]							62,240,000
		Total Net Cost				**$227,069,518**			**207,477,801**
		Net Cost per tonne				***$145.17***			***$132.64***

[1] Reference Halton Region, 2004 figures along with the estimated inflation calculation (waste management cost and material revenues escalate 2% annually from 2003 to 2008)
[2] Tipping fee for materials sent to an EFW facility of $129 per tonne (Reference Peel Region, 2004)
[3] Bottom ash from EFW (144249t)
[4] Both steel and aluminum are recovered from EFW ash and sold at same unit revenue as materials from recycling Al recovered 11,108t, steel 28478t
[5] Credit for electricity = difference in energy when residue sent to EFW versus residue sent to landfill (778 million kwh) at $0.08/kwh

Appendix C: Full Cost Summary for Scenario Three and Scenario Five

			Scenario Three				Scenario Five		
Generation 2008	**Recovered 2008**	**Commodity**	**Net Cost of Municipal Recycling**	**Cost to Collect Residue $55/t[1]**	**Cost to Landfill Residue $55/t[1]**	**Total Cost Recycling & Landfill**	**Cost to Collect Residue $55/t[1]**	**EFW Tipping Fee $142/t[2]**	**Total Cost Recycling & EFW**
675,900	405,540	Printed Paper	$18,213,407	$14,869,800	$14,869,800	$40,763,847	$14,869,800	$38,391,120	71,474,327
349,120	209,472	Paper Packaging	$84,131,979	$7,680,640	$7,680,640	$96,939,279	$7,680,640	$19,830,016	111,642,635
233,030	139,818	Plastic Packaging	$191,809,182	$5,126,660	$5,126,660	$198,502,022	$5,126,660	$13,236,104	210,171,946
71,190	42,714	Steel Packaging	$10,538,263	$1,566,180	$1,566,180	$12,715,383	$1,566,180	$4,043,592	16,148,035
27,770	16,662	Aluminum Packaging	-$11,470,505	$610,940	$610,940	-$6,301,825	$610,940	$1,577,336	-9,282,229
207,170	124,302	Glass Packaging	$21,432,280	$4,557,740	$4,557,740	$60,401,980	$4,557,740	$11,767,256	37,757,276
1,564,180	938,508	**Total**	**$314,654,606**	**$34,411,960**	**$34,411,960**	**$383,478,526**	$34,411,960	$88,845,424	**437,911,990**
		Cost to landfill Bottom Ash[3]							7,212,450
		Credit Steel from EFW[4]							1,345,586
		Credit Al. from EFW[4]							17,603,847
		Credit Electr. from EFW[5]							50,880,000
		Total Net Cost				**$383,478,526**			**375,295,007**
		Net Cost per tonne				***$245.16***			***$239.93***

[1] Reference Halton Region, 2004 figures along with the estimated inflation calculation (waste management cost and material revenues escalate 2% annually from 2003 to 2008)
[2] Tipping fee for materials sent to an EFW facility of $129 per tonne (Reference Peel Region, 2004)
[3] Bottom ash from EFW (144249t)
[4] Both steel and aluminum are recovered from EFW ash and sold at same unit revenue as materials from recycling Al recovered 11,108t, steel 28478t
[5] Credit for electricity = difference in energy when residue s ent to EFW versus residue sent to landfill (778 million kwh) at $0.08/kwh

Appendix D: Full Cost Summary Scenario Two and Scenario Six

			Scenario Two				Scenario Six		
Generation 2008	**Recovered 2008**	**Commodity**	**Net Cost of Municipal Recycling**	**Cost to Collect Residue $55/t[1]**	**Cost to Landfill Residue $55/t[1]**	**Total Cost Recycling & Landfill**	**Cost to Collect Residue $55/t[1]**	**EFW Tipping Fee $142/t[2]**	**Total Cost Recycling & EFW**
675,900	486,324	Printed Paper	$17,459,884	$10,426,680	$10,426,680	$36,009,624	$10,426,680	$26,919,792	54,806,356
349,120	201,428	Paper Packaging	$77,688,665	$8,123,060	$8,123,060	$96,350,055	$8,123,060	$20,972,264	106,783,989
233,030	41,424	Plastic Packaging	$39,531,406	$10,538,330	$10,538,330	$51,439,786	$10,538,330	$27,208,052	77,277,788
71,190	46,280	Steel Packaging	$11,417,975	$1,370,050	$1,370,050	$13,293,090	$1,370,050	$3,537,220	16,325,245
27,770	18,587	Aluminum Packaging	-$12,795,719	$505,065	$505,065	-$8,872,349	$505,065	$1,303,986	-10,986,668
207,170	145,019	Glass Packaging	$25,004,327	$3,418,305	$3,418,305	$62,804,122	$3,418,305	$8,825,442	37,248,074
1,564,180	939,062	**Total**	**$158,306,538**	**$34,381,490**	**$34,381,490**	**$227,069,518**	$34,381,490	$88,766,756	**281,454,784**
		Cost to landfill Bottom Ash[3]							7,212,450
		Credit Steel from EFW[4]							1,345,586
		Credit Al. from EFW[4]							17,603,847
		Credit Electr. from EFW[5]							163,520,000
		Total Net Cost				**$227,069,518**			**106,197,801**
		Net Cost per tonne				***$145.17***			***$67.89***

[1] Reference Halton Region, 2004 figures along with the estimated inflation calculation (waste management cost and material revenues escalate 2% annually from 2003 to 2008)
[2] Tipping fee for materials sent to an EFW facility of $129 per tonne (Reference Peel Region, 2004)
[3] Bottom ash from EFW (144249t)
[4] Both steel and aluminum are recovered from EFW ash and sold at same unit revenue as materials from recycling Al recovered 11,108t, steel 28478t
[5] Credit for electricity = difference in energy when residue sent to EFW versus residue sent to landfill (778 million kwh) at $0.08/kwh