Thinking "Beyond the Box" – an examination of collection mediums for printed paper and packaging waste.

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Executive Summary

Across Canada, provinces are revisiting the legislative frameworks for residential recycling programs (from who is physically and financially responsible for end of life material, to what it means to have a successful recycling program). As the next stage in producer responsibility programs are debated and China's National Sword Initiative has challenged the existing recycling model, there is an opportunity for municipalities to take another look at better and best practices in how best to collect material, and this includes evaluating whether recycling bags can be used to supplement and/or replace bins and carts for households. This study finds that there are demonstrable opportunities for cost savings at a comparable (or higher) level of recycling performance for municipalities who implement bag based programs. However, there is no one solution for every jurisdiction – careful consideration must be given to all options, with site and situation specific factors being accounted for. The findings from this study are meant to highlight that collection options are not limited to a box or cart – bags are a viable and potentially preferable alternative.

Salient findings from this study are:

- Recycling bags are a viable and accepted alternative to both carts and boxes for municipal printed paper and packaging
- On average, programs that utilize bag only, or a combination of both bag and box collection, recycle more than municipalities who opt for cart based collection
- On average, programs that utilize bag based collection receive higher revenues from the sale of recyclable material than both box and cart based programs
- The transition to recycling carts for municipalities across Canada has resulted in a significant increase in the cost of material management over time (net cost per tonne) and decrease in realized revenues
- Municipal waste operators are supportive of adopting bags, subject to a series of conditions (i.e. external investments for bag breakers etc.)
- Recycling bags are extremely effective at adding "marginal capacity" to a recycling system – the household incurred cost is merely the cost of a plastic bag (pennies)
- Municipal and private operators feel as though reduced incidences of work place related injury and labor time rationalize the use of carts, irrespective of higher levels of contamination

1.0 Introduction

The Blue Box has become a ubiquitous fixture in residential recycling programs across North America. For millions of homes, participation in municipal recycling programs involves setting

out printed paper and packaging curbside for collection by the municipality/service contractor. While bins and carts have historically been the primary collection medium for household packaging waste, increasingly, recycling bags are being adopted as potentially viable alternative. This study examines the viability of recycling bags as a collection medium for household recyclables (namely printed paper and packaging materials). In doing so, the economics, infrastructural opportunities and impediments as well as stakeholder attitudes towards recycling bags are considered.

It should be noted that York University does not represent the interests of any particular organization or commercial entity. The university was retained by Clorox Company to evaluate the merits of recycling bags as a potential collection medium, but gave the research team complete discretion and latitude with respect to how the study was to be conducted and the results communicated.

This paper is structured as follows:

- Review of the broader literature/experiences from jurisdictions across North America
- A description of materials and methods
- A discussion surrounding the economics and environmental impacts of bag based programs, including a comparison with cart/bin based programs
- Summary of survey results with recycling system operators
- Conclusions and Recommendations

2.0 Findings from broader literature review

This section summarizes and compares municipal/private operator experiences with bags, bins and cards, as well as the reported advantages and disadvantages of bag based programs as reported by other jurisdictions. This is not intended to reflect the findings of this particular study, but merely quickly summarize the findings observed in the broader literature.

2.1: Comparison of Bags, Boxes, and Carts

	Bag	**Box**	**Cart (* indicates automated collection)**
Cost	(+) Lower all in cost when compared to boxes/carts (-) Ongoing cost for residents (-) Cost for specialized processing materials and extra sort staff	(+) One time cost (-) May be expensive for municipality to provide (-) Replacement/repair costs	(+) One time cost (Minus 5% annual breakage) (-) May be expensive for municipality to provide, implement and operate (a cost born by all stakeholders)

			(-) Replacement/repair costs (-) Cost for specialized collection trucks & maintenance
Capacity	(+) Increased capacity; unlimited recycling	(-) Low capacity; multiple boxes needed (-) May throw items in garbage if no room in box	(+) large capacity, can hold more than a blue box (but not unlimited) (+) Can be stored longer between collection
Processing	(-) Additional processing infrastructure required (-) Recyclable material may remain in bags	(+) Loose material at MRF, decreases processing time (+) No additional infrastructure needed	(+) Loose material at MRF, decreases processing time (+) No additional infrastructure needed
Contamination	(+) Less opportunity for items to become wet. (+) Collectors can scan for contaminants IF see-through	(+) Collectors can screen for contaminants. (-) Items can become wet	(+) Drier recyclables (+) Cameras installed in trucks to screen for contaminants* (-) Harder to monitor and screen for contaminants (-) Residents can hide non-recyclables in cart (-) Snow can be knocked off wheels into truck making materials wet
Collection	(+) Quick & easy to collect (-) Only manual collection (-) Time consuming to collect from multi-residential with large volume of bags (-) Potential safety risks (broken glass, needles)	(-) Materials can be dumped during collection (-) Only manual collection	(+) Option for automated collection (+) Option for RIFD (+) Can be collected from snowbanks* (+) Can reduce crew size* (+) Reduces worker health and safety risks* (-) Average stop times between 20 and 30 seconds. (-) Difficult to service some multi-family

			buildings due to space constraints. (-) Longer stop times per household will result in higher emissions and fuel consumption. The magnitude of this impact is contingent on the type of vehicle being used (LNG vs. Diesel etc.)
Durability	(+) Protected from wind/rain (-) Bags can break/tear (-) Animals can get into bags	(-) Materials not protected from wind/rain/snow (-) Boxes can crack/break (-) Attracts vermin due to open container	(+) Protected from wind/rain (+) Protected from animals
Ease of use	(+) Easy for residents to handle (+) Low storage requirement	(-) Requires covered storage area (-) May be difficult to handle in multi-residential/walk-ups (-) Required to collect box from curb after collection	(-) Large storage requirement (-) Required to collect box from curb after collection (-) Can be difficult for seniors/those with disabilities to handle
Other	(-) Bags may not be recyclable and create more waste	(+) 2-4 year life span on average (+) Made out of HDPE recyclable resin (-) Not often recycled at end of life (broken blue bins often end up in the landfill)	(+) 10 year lifespan on average (-) Not often recycled at end of life due to size

Commentary

While the above is hardly an exhaustive list of the purported experiences with bags/bins/carts, it does provide some useful information and context when understanding why a municipality may opt for a particular collection medium.

However, these findings must be interpreted with a degree of caution – often times, the full impact of any programmatic change can only be considered in the long run, and thus, asserting the efficacy of one collection medium or another may be pre-mature. Related to this point, is that the economic and operational implications of selecting a particular collection medium is evaluated in isolation – i.e. a municipality who opts for carts will only evaluate how their own individual costs and diversion has changed. In order to fully understand the merits and viability of a particular approach, a "macro" level examination must be performed to see how municipalities compare with one another, provincial averages, and over time.

This desire to understand the broader trends and findings of bags vs carts/boxes largely served as the impetus to this study. The ultimate goal was to better understand the benefits and drawbacks of each collection medium, and supporting evidence using best available data provided by municipal and provincial sources.

3.0 Materials and Methods

This study employs a mixed methods research approach that combines quantitative and qualitative data from jurisdictions/provinces across Canada. This was done to facilitate credible and meaningful analysis regarding the efficacy of recycling bags, bins and carts.

Quantitative Data Sources:

This study used a combination of panel data from the following sources:

- WDO/RPRA Data Call: Contains household recycling data for 223 Ontario municipalities over between 2004-2016
- Multi-Material Stewardship Manitoba Annual Reports: Contains household recycling data for the printed paper and packaging steam between 2010-2016
- Eco Enterprise Quebec Annual Reports: Contains household recycling data for the printed paper and packaging steam between 2011-2016
- Multi Material Stewardship BC/Recycle BC Annual Reports: Contains household recycling data for the printed paper and packaging steam between 2014-2016
- Continuous Improvement Fund: Individual reports related to projects involving the purchase of Blue Bins, or the transition to cart based systems

A qualitative dimension was also included (structured interviews with waste operators) to complement the empirical component of this study. This was done to provide additional context and color to the data being examined.

Structured interviews and surveys were developed in an attempt to gauge the attitudes and opinions of recycling stakeholders regarding Material Recycling Facility Operations and attitudes towards the use of recycling plastic bags as a collection medium.

Interview participants were selected on the basis that they represented either a collector or processor of household packaging waste – this included both a mix of municipal sector actors and private contractors.

A request for participation was sent via email to potential study participants. This correspondence outlined the purpose of the study, what the data and findings would be used for, and what results would be shared with potential participants. Surveys were completed via electronic correspondence, or if necessary, over the phone with the results being transcribed by hand via the enumerator. How the survey was administered was decided by interviewees, with all results electronically recorded and archived to York University's Waste Wiki team.

A high-level summary highlighting the purpose of the study and a conceptual overview of the issues being examined was disseminated two weeks prior to the official release of the finalized survey. This was done to ensure that participants had sufficient time to review the outcome of the analysis and seek clarity on any issues surrounding methodology, findings, etc. Questionnaires were pre-tested and refined prior to conducting the official survey. The pre-test allowed for wording refinements and changes to the ordering of the questions. The finalized survey was conducted over a 10-week period beginning in November 2017 and running through the second week of January 2018.

Respondents were asked to answer questions using a combination of Likert scales and open-ended statements. Depending on how the survey was administered, respondents were either: a) read questions and asked to mark their responses on the survey with the assistance of an enumerator, or b) asked to complete the survey electronically and submit their responses via email to the project lead. Electronic surveys included a contact number and email for the project lead, in the event that the respondent required assistance in completing the questionnaire.

A total of 114 stakeholders were contacted and asked to participate in the study. Of those contacted, 22 respondents successfully completed the survey, for a response rate of 19.3%. It should be noted that while this sample underrepresents municipal waste managers from rural and northern municipalities outside of major urban centers (when measured by the number of municipalities across Canada).

3.1 Research Stages and Data Preparation

This study used a two stage research approach. The first stage involved analyzing the data provided by annual reports, the RPRA data call etc. to determine what relationship, if any, exists between the collection method (bags/bins/carts) and recycling system performance. For the purposes of this study, we define recycling system performance using the following metrics:

- Material Management Costs
- Recycling Rates
- Contamination Levels

- Material Specific Revenues

In order to compare results across jurisdictions etc. “grouping” of data was required to ensure that the study team was adhering to the “like with like” principal. As an example, comparing the City of Toronto with the Township of Killarney does not provide meaningful insights – locality, population density, distance to MRFs, local labor markets etc. all influence a municipalities recycling system performance. Attempting to isolate or attribute difference in costs or recycling rates to the collection medium being utilized is an impossible task.

This ultimately necessitates that the data be reorganized such that programs who share similar demographic/infrastructural characteristics are grouped and compared with one another. Where possible, pre-existing municipal groups as defined by the province (i.e. RPRA municipal groupings) were used to organize and compare municipalities.

Broadly speaking, municipalities have been grouped into the following four categories:

Large Urban Programs: Municipalities with high populations and population densities. Characterized by a mix of single family and multi residential buildings (e.g. Toronto, Montreal, Peel and Vancouver). It should be noted that Halifax and Edmonton have been characterized as large urban programs for the purposes of our analysis so as to reflect larger provincial programs that also use bags for recycling collection.

Medium Urban Programs: Medium sized municipalities characterized by high populations, but not necessarily as densely populated as municipalities in group 1. Less prevalence of multi-residential buildings (e.g. Durham, Windsor, Winnipeg)

Rural Programs: Small communities with low population densities. This includes both rural communities located on the periphery of urban areas (e.g. Wellington, Dundas), as well as northern communities where factors such as seasonality may affect a municipality’s ability to offer curbside collection.

Given the difficulties in making direct comparisons between municipalities, this study sought to place greater emphasis on how the decision to implement a bin, bag or cart affects recycling performance over time. The intertemporal nature of the data included in this study allows us to identify when a particular programmatic change was implemented (i.e. Toronto’s decision to switch from a box to cart in 2010) and evaluate how recycling rates and costs have changed since. Arguably, this provides more useful insights into the efficacy of particular collection medium, as it inherently controls for infrastructural/demographic characteristics that exist across municipalities.

The second stage of this research involved interviews with recycling stakeholders, as described above.

4.0 Results and Discussion

This section has been broken down into three areas – (expressed on a per tonne basis), a comparison of recycling rate performance, a comparison of recycling system costs and a comparison of revenue levels and contamination rates (where contamination is defined as either materials placed in the Blue Bin/Bag/Cart, or "soiled" Blue Box materials that cannot be recycled as a result of being wet, containing food residue etc.)

Where appropriate, performance over time metrics have been included, to illustrate the impact of a municipality switching collection mediums (cart to bin, bag to bin etc.).

A decision was made to aggregate municipal entries such that no one municipality is singled out in this report. Results are communicated as weighted averages, and grouped according to locality and collection medium. While doing so perhaps comes at the expense of accuracy, there are often exogenous factors that drive a municipalities recycling system performance, that are outside of their ability to directly control (as an example, density of multi residential buildings). Singling out any one municipality as being a "better" or "poor" performer may not only be unfair, but introduce a political dimension to this study that would detract from credibility or meaningfulness of the findings.

4.1 Recycling System Performance

Figure 1: Recycling Rate Performance (Bag vs Bin vs Cart) – All Municipal Groups

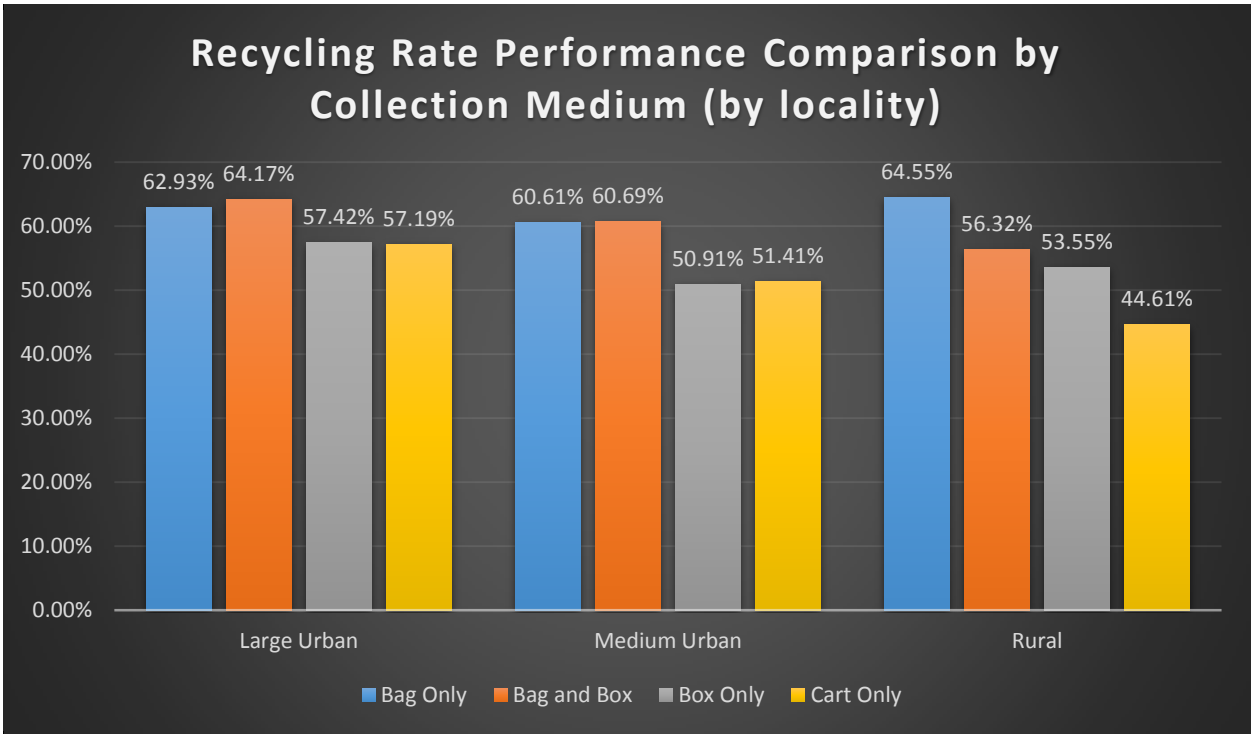


Figure 1 above compares the relative recycling rate performance of “bag only”, “bag and box”, “box only” and “cart only” programs for the municipalities included in this study. These recycling rates reflect the weighted average for each of these groups, with outliers (programs that report recycling rates of 0, or in excess of 100%) removed from the analysis.

Of note, relatively few municipalities classified as “Large Urban” exclusively uses recycling bags to collect household recyclables. However, a number larger programs (such as Peel Region) employ a combination collection method wherein residents are able to use a combination of either a cart/bin with a recycling bag, to reduce constraints on recycling capacity and maximize recycling participation.

The ability to add “marginal capacity” via recycling bags is demonstrably successful (for reasons that will be elaborated on in greater detail later in this section). As shown in Figure 1, municipalities that allow residents to use bags in conjunction with existing bags/carts recycle between 11% and 18% more than those that rely on a single form of collection

While it is difficult, if not impossible, to specifically attribute this increase in recycling rate to just recycling bags, the ability for households to add marginal capacity at the curb via a bag seemingly encourages increased diversion.

This finding is principally consistent with what was found by Lakhan’s 2015 study on Pay as you throw systems in Ontario, which stated that there was insufficient capacity in household Blue Bins to accommodate for the quantities of materials being generated. This ultimately resulted in excess material being placed in the garbage stream, necessitating that additional capacity be added. Lakhan’s study also found that households were unwilling to incur a time/monetary cost to procure an additional Blue Bin from the municipality. This suggests that if adding capacity was made convenient for households(in the form of purchasing bags at a grocery store), households would be less inclined to place recyclables in the garbage stream, encouraging recycling.

Given that many municipalities are opting for bi-weekly collection of both recyclables and garbage (as a means to encourage recycling and decrease operational costs), the ability to easily and cheaply add capacity (via a recycling bag etc.) will be critical moving forward.

4.2: Net System Cost Performance

Figure 2: Recycling system cost (Bag vs Bin vs Cart) – All Municipal Groups

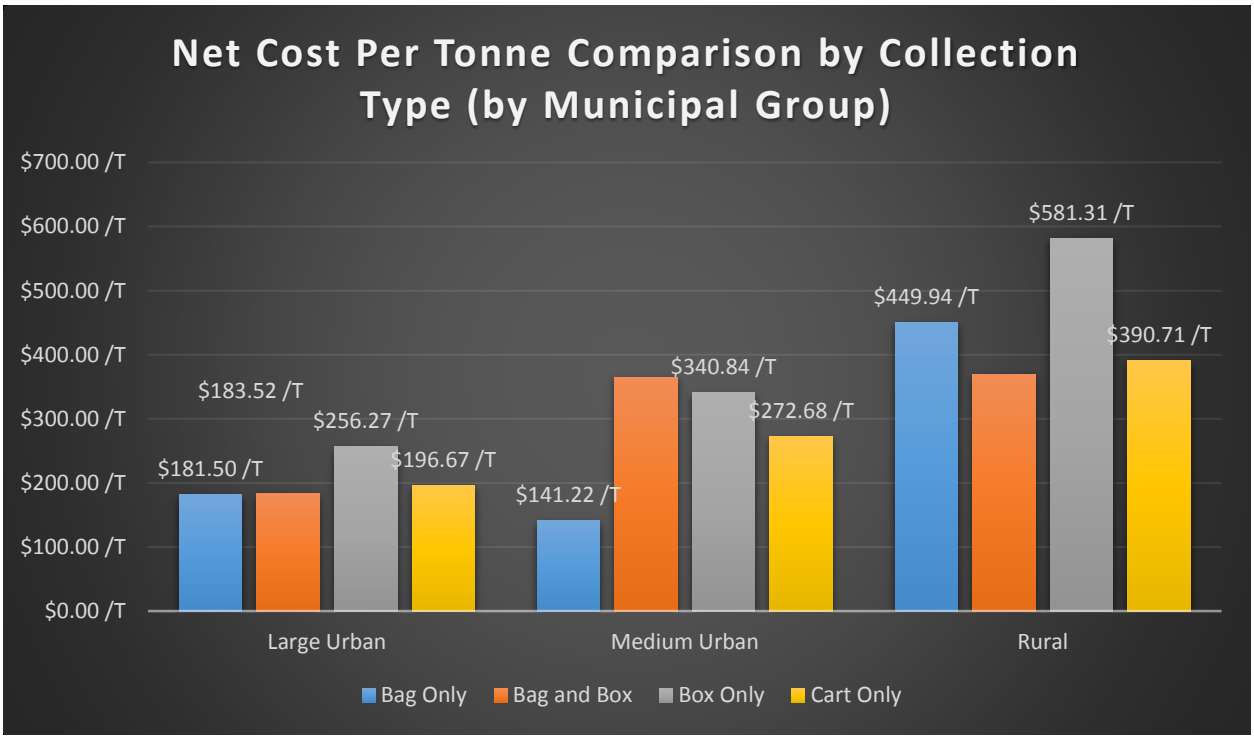


Figure 2 above compares the relative net cost per tonnes for various collection mediums, and organized by locality.

For both Large Urban and Medium Urban communities, bag based programs were less costly to operate (particularly in medium urban communities, where net costs were more than halved). It should be noted that rural communities contain a number of anomalies where programs report net costs in excess of $2000 a tonne. As such, those results should be interpreted with a degree of caution, as the inclusion of outliers in the data set may be artificially skewing the data.

While it is difficult to specifically isolate whether these cost savings are attributable exclusively to the use of bags, it does support the position that bag based programs are cheaper to operate when compared to box/cart based programs. This is largely due to the capitally intensive nature of operating a cart based program (particularly at a program's onset), which requires specially configured collection vehicles and the provision of carts to residents. It should be noted that proponents of cart based collection point to increases in collected tonnes, lower rates of work place related injury and reduced labor costs due to lower truck operator hours. Whether these benefits rationalize the capital required to operate a cart based program is dependent on site and situation specific factors.

However, the findings from this report highlight that it is dangerous for municipal officials to assume what works best and why. Cart and box based programs are appropriate under certain circumstances, but they should not be presumed as the best available options. As shown in

Figures 1 and 2, bag based collection offers a cost competitive alternative that offers comparable (and in some instances, superior) recycling rate performance.

The direct effects of cart based systems on processing costs is also indeterminate, as higher rates of contamination associated with cart based programs require additional sorters and/or technologies to remove contaminated materials from the sort line. Conversely, the use of cart based systems forgoes the need to have bag breakers and film screens on the sortation line, which could potentially result in a savings for a municipality.

4.3 Contamination

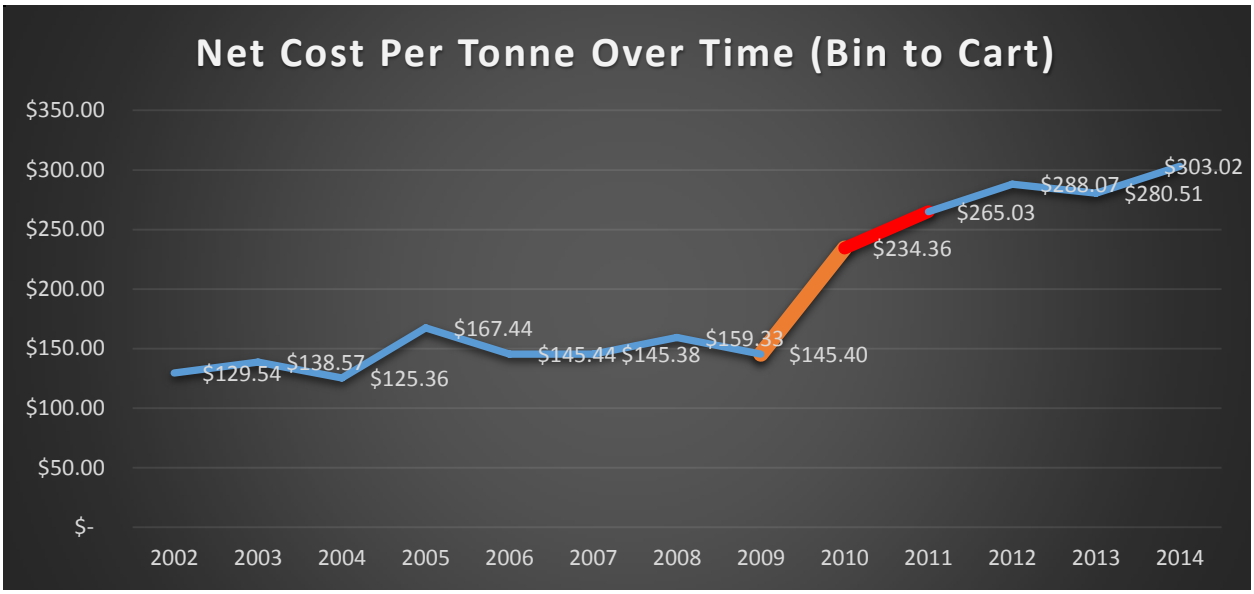
The issue of recyclable contamination is perhaps the most salient in discussions surrounding recycling bags, bins and carts. While our analysis surrounding net costs per tonne do not provide any specific guidance regarding which collection medium to choose, contamination rates adversely impact realized revenues for municipalities. The magnitude of this impact may be sufficient to negatively impact net material management costs, and even culminate in a scenario where end markets/processers reject bales as a result of contamination (i.e. a possible explanation for the Chinese recycled plastics ban)

While this point will be expounded upon in section 4.4, reported rates of contamination associated with cart based programs range between 15-25%. Of the 24 programs for which data could be obtained regarding historical rates of contamination – on average, cart based programs resulted in an 8% increase in contamination rates relative to bag and/or bag + bin programs.

For some municipalities who transitioned from box to cart based programs, reported contamination rates more than doubled. While it is difficult to specifically isolate the impact of increased contamination rates on municipal recycling costs, Figure 3 below summarizes the weighted average net cost per tonne for programs that have transitioned to cart based programs over the past 12 years.

Of note, between the periods of 2009 and 2011, 3 major urban municipalities in Ontario transitioned from a Blue Box to Cart based programs. During this period, the weighted average net cost per tonne increased by more than 18%. While it would be disingenuous to attribute the entirety of this cost increase to the switch to carts, it does speak to the negative impacts cart contamination can have on recycling costs.

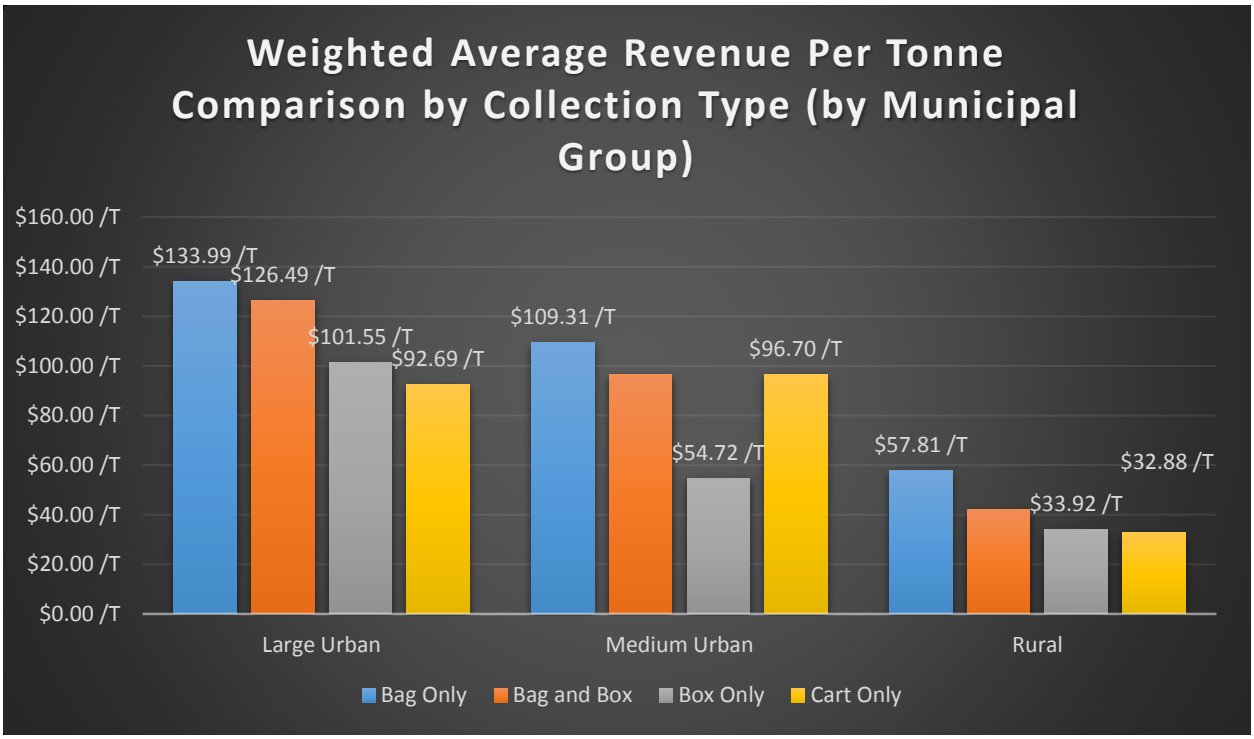
Figure 3: Net Cost per Tonne for Programs that transitioned to cart



Based on feedback provided by recycling stakeholders, this increase in cost is primarily the result of the decrease in revenue as a result of higher rates of contamination (from light weight plastics, composites etc.). Simply put, municipalities are receiving less for baled materials resulting from cart based contamination.

Figure 4 shows the weighted average revenue for tonne for different collection mediums, sorted by municipal group.

Figure 4: Weighted Average Revenue per Tonne (By Municipal Group)



However, for the Medium Urban, Rural and Rural Northern municipal groups, bag only programs report demonstrably higher revenues than both box and cart based programs. It is worth noting that there are far fewer programs that are exclusively bag based programs, so this result should be interpreted with caution.

However, based on best available data, there is a clear relationship between realized revenues and the collection medium being used. As an ordinal ranking, bags results in higher revenues than both boxes and carts, and boxes result in a higher revenue than exclusively carts.

4.4 Qualitative Feedback from Recycling Stakeholders

This section summarizes the qualitative findings from the surveys with recycling stakeholders that examined attitudes towards bag based recyclable collection. While this study did receive completed surveys from 22 participants, it should be noted that this does not meet the threshold for statistical significance (given that there are more than 300+ MRF/transfer station operators publicly listed in Canada, more than 90 surveys would have been required).

As such, these findings should be interpreted with caution (and as a better practice, all qualitative data should be), and be used to offer directional guidance as opposed to arriving at a specific answer.

This section is organized into three key sections that summarize the thematic findings from our study.

At a broadly high level, we asked stakeholders to comment on the perceived advantages, disadvantages and considerations for carts/bags/bins. These results are summarized section 4.41

Stakeholders were also specifically asked whether they thought bags could be considered a viable option for collecting households for municipalities. If so, what would be the enabling factors required? If not, what were the primary impediments?

4.41: General Findings from Survey Results

1: Bags

Advantages

- Items are enclosed and protected from the elements.
    - Prevents items from being blown around and scattered in windy conditions.
    - Protects items from rain/snow and prevents them from becoming wet.
- Increased capacity.
    - Residents can put out as many bags as needed to hold all recyclables (versus just having one blue box).
- Potential to reduce contamination.
    - Because items are enclosed in bag there is less opportunity for them to become wet.
    - Collectors can scan see-through bags for contaminants.
- Easier for residents and collectors to handle.
    - Collectors can easily toss bags into the truck.
    - Bags are faster on average to collect, resulting in less time and effort to collect per household.
    - Bags can be carried with one hand, making them convenient for residents in multi-residential buildings or walk-ups to transport.
    - No additional effort required by residents once they drop bag at curb (do not need to collect boxes after pick-up).
- Eliminates blue box distribution and replacement costs incurred by municipalities.

Disadvantages:

- Bags can break and tear
    - Potential for breakage from overfilling of bags.
    - Scavengers may rip open bags and dump contents while looking for items with deposits.
    - Rodents, birds, and other animals may break apart bags.
- Potential for processing & collection inefficiencies
    - Specific technologies required at MRFs to deal with bags, such as bag-breaker technology. Otherwise it can be time consuming for staff to open bags manually.
    - Bags must be collected manually.
    - Recyclable material may not be completely removed and remain inside the bags at the MRF.

    - May be difficult and time consuming to collect bags from multi-residential units given the volume produced.
- Plastic bags may not be recyclable and create waste.
    - If the blue bags are not recyclable, they create more garbage.
    - Whether the material can be recycled can depend on market specification for blue film as well as the degree of moisture and contamination in the bags.
    - Large amounts of blue bags may reduce price that can be obtained for material.
- Issues for collectors
    - Potential safety risk for collectors if sharp objects like broken glass or needles are placed in bags.
    - It can be difficult for collectors to determine what is in the recycling bag.
    - If improper bags are used, recycling may be mistaken for garbage by collector.

2: Boxes

i. Boxes

Advantages:

- Durable (average replacement required every four years).
    - Boxes either provided to residents by the municipality or can be purchased by residents at a low cost.
- Decrease is processing times at MRF
    - Box loads can be dumped directly onto sorting lines, which reduces processing times.
    - No additional infrastructure is required (ex. Bag-breaker technology).
- Collectors can screen for contaminants
    - Collection staff can screen for contamination and improper materials at time of collection and reject unacceptable materials.

Disadvantages:

- Contents not protected from the elements.
    - If not properly loaded, materials can blow out of the open boxes in windy conditions, creating litter.
    - Materials are susceptible to rain and snow.
- Low capacity.
    - People are limited by the size of the boxes. Given the number of materials now collected by the program, boxes may be too small.
    - If there is not enough space in the blue box, residents may instead throw recyclable materials into the garbage.
    - Residents are generally required to cover the cost of additional boxes.
    - Multi boxes increases collection times and associated costs.
- Issues for Residents
    - Boxes require a covered storage area.

    - Storage can become an issue if residents require multiple blue boxes. Storage may be an issue in multi-residential buildings.
    - May be difficult for residents to handle multiple blue boxes. Blue boxes may also be difficult for people living in multi-residential buildings or walk-ups to handle.
    - Resident required to pick-up blue box from the curb following collection. May be inconvenience for residents on large lots with long drive-ways.
- Collection Issues
    - Materials can accidently be dumped during collection and missed.
    - Because of the number of boxes needed by residents to contain all their recyclables, boxes may not work well with a bi-weekly recycling collection system.
- Boxes can potentially crack or break.
- It is easy for scavengers to steal materials from boxes or the boxes themselves.
- Can be expensive for the municipality to provide all their residents with boxes.

ii: Carts

Advantages:

- Materials are protected from the elements and from animals.
    - Because of the lid on the cart materials are protected from rain/snow. This also reduces issues with animals and rodents.
    - With automated collection carts can be collected from snowbanks.
    - Carts can withstand windy conditions of 50-60kms/hour without tipping over or the lid blowing off.
- Large capacity
    - Residents can place more items in their cart than they could with a blue box.
    - Can send a visual cue and encourage more recycling.
    - Additional capacity means carts can be stored longer between collections. This can lower collection frequency and in turn, lower collection costs.
- Option for automated and semi-automated collection.
    - Automated collection can reduce the number of employees required
    - Automated collection minimizes exposure to sharp objects, repetitive strain injuries, physical fatigue, and exposure or risk of injury from weather and traffic risks.
        - This can reduce WCB claims, insurance premiums, and sick leave.
    - Automated collection eliminates gender and age biases and allows for a more diverse workforce.
- Option for RFID (Radio Frequency Identification Device) systems.
    - Can gather more specific collection data, history of cart over lifetime, data on participation rates.
    - Can target education in areas with poor set out and contamination issues.

Disadvantages:

- Capital investment required

    - Capital costs for carts range from $30 to $60 depending on size.
    - Not feasible for residents to purchase carts given costs, so burden is put on the municipality.
    - Home-owners may try to take carts with them when they move.
    - Automated collection also requires specialized trucks. These tucks are almost twice the cost of manual collection trucks and require additional maintenance for automated arm.
- Space requirements
    - Carts are the largest of the three options and require the most storage space. May be an issue in high density municipalities.
    - May be space limitations when trying to collect carts in lanes and small cul-de-sacs.
- Issues for residents
    - Resident required to pick-up cart from the curb following collection. May be inconvenience for residents on large lots with long drive-ways.
    - Can place a burden on the senior population and those with disabilities.
- Contamination
    - It is harder for collectors to monitor, control, and remove contaminants.
    - Residents can hide non-recyclable materials in the cart. This could be an issue where the garbage bag allowances are low or it is costly to put out additional bags.
    - Snow can cling to the cart wheels and potentially be knocked into collection vehicle, making recyclables wet.
    - Estimated minimum increase of approximately 5-6% in residual rates with auto-collection program.

4.5 Thematic Findings from Surveys

4.51 Advantages of Recycling Bags

Adoption of Blue Bag

Almost universally, stakeholders who operated MRFs indicated that they would be willing to implement bag breakers and film screens on their line, subject that the cost of doing so was subsidized (in part, or in total) by a third party (municipality, CIF, Industry Funded Organization etc.). Many MRF operators indicated that capital budgets were already extremely thin, and making additional investments without a demonstrable return would be unlikely.

While these are indeed valid concerns, it is worth noting that increases in material revenue resulting from the switch to bag based programs may help offset/supersede any upfront costs required from the municipality. During a survey conducted over the telephone, an anecdote was made that if two sorting workers stood at the bag of the film screen, they should be able to positively pick contaminants out of the main line.

Bags help reduce contamination levels

Approximately 80% of survey respondents agreed, or strongly agreed, with the statement "Using Recycling Bags helps prevent household recyclable contamination". A noted in section 4, contamination rates in the province are trending upwards, particularly for programs who have opted for the use of recycling carts. Recycling bags present a readily available "turnkey" solution that not only achieves comparable (or superior) levels of diversion, but helps deter against household littering.

Bags encourage household participation

While it was ultimately outside the scope of this study to gauge household attitudes towards recycling bags, waste operators posited that households would readily embrace the recycling bag (given the precedent of using bags with our garbage stream). Anecdotes recorded during surveys suggested that "bags were cheap and available at any corner store" and that "it was easy for households to add recycling capacity at the curb, assuming the municipality didn't try and stop them from using bags".

It is the recommendation of this study that a comprehensive household survey be developed to gauge and observe household attitudes towards clear bags – as far as can be ascertained, to date, no study has been conducted in this area in a Canadian context. Gathering this information surrounding household attitudes and stated/observed preferences would significantly improve our understanding of recycling in general, and hopefully provide insights into which collection medium is ultimately the most effective.

Bags prevent litter

More than 90% of all survey respondents either agreed, or strongly agreed with the statement "The use of plastic recycling bags prevents litter at the curb". Curbside litter has become an increasing concern for municipalities, both with respect to maintaining the public aesthetic, and the operational costs of having to collect errant litter that blows onto the street from open blue bins.

Recycling bags were seen as a relatively "easy fix" to this problem, with 72% of respondents indicating that they had a preference for the use of recycling bags in lieu of recycling carts, when it came to addressing curbside litter.

Ease of Adding Capacity/Purchase

More than 90% of survey respondents surveyed selected recycling bags as the most convenient method for purchasing recyclable capacity (when asked to choose between purchasing recycling bags from the grocery store, or Blue Bins/Carts from the municipality). While this may suggest that respondents are in favor of recycling bags relative to other collection mediums, keep in mind that our audience in this case was waste service providers. A much more meaningful study would be to gauge household attitudes and utilization of recycling bags, but such a study has not been completed to date.

4.52 Disadvantages of recycling bags

Recycling Carts results in an increase in overall tonnes collected

The majority of survey respondent indicated that the use of recyclable carts would results in the greatest overall diversion, relative to other collection mediums (box/bin). Anecdotally, waste operators feel as though carts are convenient for households, remove restrictions on capacity, and when used in conjunction with bi-weekly garbage collection, incentivizes recycling behavior. While our data does not principally refute these findings (although one could contend that cart based programs are not outperforming like municipalities who opt for a box or box/bag), comments made by stakeholders do not reflect that overall diversion may not even be an appropriate goal.

While both policy makers and the public have been inundated with messaging that "diversion is good", increasingly it is becoming more apparent that what/how something is being diverted is equally important as the sheer quantity being diverted.

Cart based collection results in fewer work place related injuries

All survey participants indicated that cart based collection reduced the frequency of injury and workers compensation claims.

Moving from manual collection to automated collection allows for a reduction in costs related to:

- Staff injuries
- Illness rates
- Modified job duties
- Reduced WSIB claims

This occurs because carts minimize exposure to sharps and broken class, repetitive strain to shoulders, knees and back and helps drivers avoid exposure to traffic risks while working on the side of the road.

The City of Guelph experienced a 62% savings in replacement labour costs after transitioning to automated services. In the case of Bluewater Recycling Association and the City of Guelph, WSIB claims fell by 92% and 90% respectively.

The City of Guelph experienced a $107,000 reduction in lost time and replacement labor costs in the 2 year period immediately following the transition to cart based collection.

Using data provided by CIF Report(s) #284, #888, #566.4, the average number of lost hours attributable to work place related injury reduced from 22 hours (per driver) for every 1000 hours of driving time, to 6.8 hours/1000 driving hours. Assuming that the average driver wage is approximately $35 per hour, the annual health and safety savings attributable to carts equals $532 per driver, for every 1000 hours of time on the road.

As an example, in a municipality with 10 drivers working 40 hours per week, collecting 10,000T of recyclables, the overall annualized savings in replacement labor cost would be $110,656.

However, one must also factor in the additional cost incurred by operating a fully automated system, which as shown in section 4.2, is $15.17/tonne greater than programs who operate bag based programs.

In our example above, a municipality collecting 10,000T of recyclables using a cart based system would be $151,700 more expensive when compared to a bag based program.

The reduction in workplace related injuries compares favorably to other occupations characterized by high degrees of manual labor. The average lost hours per 1000 hours worked (calculated using lost labor days per year) is:

- Parks and recreation employee: 19 loss hours /1000 work hours
- Bus Driver: 31 loss hours/1000 work hours
- General Laborer: 15 loss hours/1000 work hours
- Heavy Machine Operator (Construction): 16 loss hours/1000 work hours

Collection times are reduced using cart based programs

More than half of all survey respondents indicated that cart based collection results in fewer overall operator hours and reduced on the road time relative to both box and bag based programs. Given that cart based programs often require a single operator vehicle with a side loader, collection is, in theory, a largely mechanized process that does not require the driver to exit the vehicle. I made the qualifier of “in theory” in that many stakeholders also indicated that navigating side loading trucks to collect carts in densely populated urban areas was challenging. Due to space constraints, drivers would still often have to exit the vehicle and manually load a cart onto the truck, because they simply could not maneuver the lifting arm into place. Much like overall instances of workplace related injury, there is a need to conduct a follow up study that either confirms these assumptions or dispels them as erroneous.

Bags lack Durability

Approximately 30% of waste operators indicated that they felt recycling bags were too fragile, particularly when collected in a single compartment vehicle serviced by a single operator. Broken glass, jars, bottles etc. are capable of perforating a recycling bag, which may result in cross contamination of other materials, or recyclables being scattered at the curb.

Related to this point, many stakeholders expressed concern that clear bags may serve as vectors for vermin (raccoons, mice etc.), which could encourage scavenging. While this indeed is a valid concern, it was not entirely clear how bags significantly differed from boxes in this regard.

5.0 Conclusion and Recommendations

5.1 Opportunities for the future

The data in this study supports the consideration and implementation of recycling bags as a potential alternative (or compliment) to bin and cart based systems.

In the short term, recycling bags are a convenient and low cost option for households to add additional recycling capacity at the curbside. The incremental cost of purchasing recycling bags is nominal (as households can purchase these bags at the grocery store), and can be placed at the curbside on a discretionary basis.

When compared to the cost associated with purchasing additional bins and/or carts, recycling bags are not only a lower cost option, but arguably a more environmentally beneficial one. The resources required to manufacture a new bin or cart is a "sunk cost" – a household is required to purchase an additional unit if they wish to add additional recycling capacity at the curb, regardless of whether it is needed every week. Recycling bags are only used on an "as needed" basis – and compare favorably to carts/bins with regards to the resources required when evaluated over the lifetime of a bin/cart.

Intermediate/Long Term

While the benefits of adding incremental capacity are certainly a boon for recycling bags, the real potential for their utilization is their lower rates of contamination when compared to bins/carts.

Contamination of the printed paper and packaging stream is becoming an increasing concern for municipalities, particularly in light of the "Chinese Sword" that has largely resulted from high rates of contamination found in exported bales. While the root cause of contamination cannot be specifically attributed to any one cause (i.e. the decision to switch to cart based collection), this study does provide clear evidence that bag based programs have lower relative rates of contamination.

The underlying intuition for why this occurs is largely rooted in behavioral theory – clear bags (where neighbors/waste collectors can see what is being disposed) discourages willful contamination because of normative (peer) pressures. People don't want to be seen as not participating in an environmentally beneficial activity such as recycling, and thus, are incented (or coerced) to correctly sort recyclables.

The converse of this situation is also true, when a cart/bin is opaque, households may be more inclined to place non-recyclables inside the container. This problem is exacerbated in communities that implement a restriction on garbage set out (pay as you throw, every other week collection) and in areas where side loading vehicles are used (the truck operator does not

get out of the vehicle to look at what's in the bin/cart). There is demonstrable evidence in the broader academic literature that households will illegally dump or not source separate recyclables if they feel that they can "get away with it" and there are limitations placed on disposal.

With the above in mind, the full benefits of a bag based program are predicated on a municipality investing in a bag breaker at a material recycling facility (or additional manual sorters that can positively pick film from the line). LDPE film does pose a potential risk to mechanical sorting equipment (getting caught in equipment), and is considered as a residue/contaminant in many municipal programs.

It is the recommendation of this study that producers and MRF operators work collaboratively to identify appropriate technological solutions that can minimize contamination of the PP&P stream, and identify ways to maximize recovery at the lowest possible cost.

While this study did not specifically attempt to demonstrate that one collection is more effective than another, it did seek to utilize best available data to assist municipalities in making evidenced based decisions. Too often, "conventional wisdom" is used in lieu of meaningful quantitative analysis, and in the case of recycling bags, the conventional wisdom has resulted in a missed opportunity.

Recycling bags are a cheap, effective and recognizable method for promoting household recycling, assuming a municipality is willing to provide the enabling conditions for success – namely, allowing for bags to be accepted at the curbside. At present, many communities prohibit the use of recycling bags on the grounds that local MRFS are not equipped with bag breakers, and that it will create too much confusion for the public to have both a bin/cart and bag. Automated cart based systems are also seen as preferable due to their assumed ability to reduce rates of work place related injuries when compared to manual collection systems (bags and boxes).

As evidenced by this study, a small investment at the MRF to allow for plastic bag collection can result in significant operational savings, particularly with respect to reduced levels of contamination and higher revenues. Related to this point, even with the introduction of cart based programs, bi weekly collection still places a constraint on recyclable capacity at the curb, resulting in illegal dumping and garbage switching. Allowing households to add marginal capacity at their own discretion is not only critical for promoting recycling, but promotes an efficient system that scales in direct proportion to the demands of the user. People will only use bags on the days they need additional capacity – there is no need purchase additional containers or carts (costs that can run in the millions for municipalities), and the replacement cost is expressed in pennies on a per capita basis. It should also be noted that rates of work place related injury for manual collection systems (bag and box) were comparable to other occupations characterized by high degrees of manual labor. While automated collection does reduce work place injury claims, the magnitude of that savings must be compared with the

increased cost of transitioning to an automated system (significant upfront capital investments) .It is the recommendation of this study that moving forward, follow up research be conducted in household attitudes towards recycling bags, such that a more complete understanding of what drives household recycling behavior in order to develop both and effective and efficient recycling system.