BUILDINGS & CITIES

Meeting urban GHG reduction goals with waste diversion: multi-residential buildings

SPECIAL COLLECTION: TRANSFORMATIONAL CLIMATE ACTIONS BY CITIES

RESEARCH

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ABSTRACT

Waste diversion targets are a common characteristic of municipal climate change mitigation plans because about two-thirds of residential waste sent to landfills is degradable and thus contributes to greenhouse gas (GHG) emissions. This paper focuses on the challenge of achieving waste diversion targets in multi-residential buildings because their diversion rates are much lower than those for single-family homes. A case study of 15 high-rise condominium and cooperative housing buildings compares modes of governance by the City of Toronto and by multi-residential buildings to address waste diversion challenges. City responses to the challenges included mandatory building standards making waste diversion as convenient as garbage disposal, voluntary standards for in-suite storage of recyclables and organics, phase-in of organics collection and pay-as-you-throw collection fees, and delivery of promotion and education programs. For buildings, the responses were fines for poor-quality sorting, conversion of the garbage chute to an organics chute, the delivery of education material to residents, and monitoring bin capacity. Despite these initiatives, Toronto is very unlikely to meet its target of diverting 70% of residential waste away from disposal in landfill by 2030. Seven actions are recommended to increase the rate of diversion.

POLICY RELEVANCE

Recommended actions for Toronto and other municipalities facing similar waste diversion deficits in the multi-residential sector include: studying the potential for converting garbage chutes to organic chutes, assessing the effectiveness of different chute systems, modifying waste collection service agreements or city bylaws to incorporate obligations for promotion and education around waste diversion, revising building standards to require more space for diversion facilities inside buildings, adopting voluntary building standards for building operations, and advocating with higher levels of government to regulate packaging complexity.

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1. INTRODUCTION

Waste is a small but significant contributor to greenhouse gas (GHG) emissions for countries worldwide. In Canada, for example, the waste sector accounts for 4.1% of the country's total emissions (ECCC 2022). Of that percentage, municipal solid waste disposed in landfills was the source of 81% of the emissions, with the remainder coming from industrial wood waste landfills, composting, wastewater treatment and discharge, incineration, and open burning of waste. The landfill emissions are net of the 30% of methane emissions that were captured for energy use or flared (ECCC 2022). Diverting waste away from landfill removes not only the organic, degradable portion, which contributes to methane production, but also the non-degradable waste, which conceivably could be recycled rather than being buried. Diverting waste has become an important goal for municipalities aiming to meet GHG reduction targets. However, waste diversion faces numerous challenges, as will be illustrated in a case study of multi-residential buildings (MRBs) in the City of Toronto.

Toronto's climate change plan, TransformTO, set overarching goals of reducing GHG emissions by 65% by 2030, compared with 1990 levels, and achieving net zero by 2040 (City of Toronto 2021a). TransformTO also includes residential waste diversion targets as part of its GHG reduction strategy. The city is largely responsible for management of residential waste, while the private sector manages the vast majority of industrial, commercial, institutional, and construction waste (City of Toronto 2015).

A large portion of Toronto's population (55%) lives in MRBs (Dello 2019) and waste diversion in MRBs, particularly mid- and high-rise buildings, is more challenging than for single-family homes. Toronto is among the top three cities, along with New York City and Chicago, that have the highest number of high-rise buildings in North America (Twitty 2019). In 2021, Toronto's single-family waste diversion rate was 63%, while the multi-residential rate was only 26%, bringing the residential average down to 52% (City of Toronto 2022a). The specific nature of the challenge for multi-residential diversion in general and how well it is being addressed by City of Toronto policies and programs and by internal management of the buildings themselves is the focus of the paper.

This case study analyses condominium and cooperative multi-residential housing. Also known as multi-owned properties, both are forms of private residential government with common ownership of property (McKenzie 2005). Harris (2019) notes that, like municipal government, condominium governments are elected, make and enforce rules, collect taxes or fees, employ bureaucracies (property managers and building staff), and provide services to residents. Cooperative housing governments have similar authority. Both have an elected board of directors responsible for managing the building (or delegating management to a property management firm) and making decisions about budgets, operations, and capital investments.

The main distinction between the two housing types is the type of ownership. The condominium owner owns their unit outright and has an interest in the common elements. Members of co-ops do not own their unit but rather own shares in a non-profit corporation that owns the building and the member has a proprietary lease for the unit from the corporation (Schill *et al.* 2007). Condo owners and co-op members pay monthly fees for maintenance and upgrade of common elements such as roofing and the building's grounds. The fees typically cover a resident's share of utility costs as well, such as for water and waste collection, and may also include heating and air-conditioning (Schill *et al.* 2007). Residents pay for a building's utility costs because the services provided are from communal facilities.

Communal facilities have been identified as a major impediment to the implementation of sustainability initiatives in MRBs because of the inability to track individual usage and charge residents accordingly (Altmann *et al.* 2018). Another constraint is that major upgrades to the utility infrastructure typically require approval from a majority or a qualified majority of residents, which may be difficult to achieve (Bright & Weatherall 2017).

Both condominiums and cooperative multi-residential housing have been called a fourth order of government, below federal and provincial governments and, depending on the author, either

alongside (Harris 2019) or below (Easthope & Randolph 2009) municipal government. In the case of waste diversion, private government sits below the public municipal government since municipal government sets rules for MRBs' use of city waste services and promotes those services.

To examine the relationship between municipal government and government at the building level, we illustrate how they each participate in three modes of governing to different extents. Following Bulkeley & Kern (2006), the modes are governing by authority, governing by provision, and governing by enabling. Governing by authority refers to a government's regulatory and sanctioning authority. Governing by provision is the provision of infrastructure and services. Governing by enabling relates to the use of persuasion through tools such as financial incentives and information campaigns.

2. LITERATURE REVIEW

Previous scholarly research on factors contributing to effective or lack of effective waste diversion in MRBs has emphasized issues of convenience, in-suite storage, promotion and education (P&E), bin capacity, management support, user-pay systems, and the visibility of waste-diversion practices. Convenience, defined as ease of accessing on- or off-site MRB waste diversion facilities, has received the most attention and generated some conflicting results. Rousta *et al.* (2015) discovered that moving the recycling bins from a distant site (about 2 km away) to the property of an MRB produced a significant decrease (28%) of packaging and newsprint in the building's garbage stream. Ando & Gosselin (2005) found that container recycling rates increased as the distance between recycling bins and a resident's suite decreased. Surprisingly, they observed that the distance effect was not present for paper recycling. DiGiacomo *et al.* (2017) found that both organics and recycling diversion increased dramatically in multi-family buildings when the convenience of the diversion system was improved by shifting from bins in the basement to bins on each floor. In contrast, Yau's (2012) study of recycling in Hong Kong found no difference in the amount of recyclables collected per unit between those who had recycling bins on their floors and those who had to use a ground floor bin for recycling. He speculated that the result may have been due to concern about the cleanliness of the recycling rooms on each floor and the fact that the ground floor rooms had better ventilation. Ng (2019a) conducted a similar study in Hong Kong with similar results. Support for the possible importance of cleanliness comes from Katzev *et al.* (1993), who found a positive relationship between participation in a multi-family recycling program and the cleanliness of the recycling facilities.

Turning to in-suite space constraints, Rispo *et al.* (2015) reported that multi-family residents identified lack of space for storing recyclables as one of the main barriers to diverting waste. Ando & Gosselin (2005) found that the perception of inadequate in-suite space for storing recyclables was associated with lower recycling rates. Another issue is that of insufficient bin capacity, which can affect both the quantity of material diverted and its quality. Ordoñez *et al.* (2015: 676) identified 'mismatches between the technical system and the users' perspective' in multi-family buildings, finding that there were not enough organics diversion bins to meet demand, and this meant more organics ended up in garbage.

There have been a few studies about the role of P&E in supporting diversion in MRBs. Rousta *et al.* (2015) discovered a significant decrease (70%) of missorted items in food waste bins after distribution of new information stickers for the bins. Timlett & Williams (2009) showed that financial rewards and use of feedback stickers placed on recycling bins can have a substantial impact on reducing contamination levels. Contamination refers to the presence of items that are not recyclable in recycling bins (or items that cannot be composted in organics bins). Lansana Margai (1997) found that 27% of MRB residents reported recycling more materials after implementation of a community-based education campaign.

Three studies highlight the role of property managers, finding them to be instrumental in introducing new waste management and sustainability programs in multi-family buildings and negotiating solutions to problems as they arise (Fallde 2015; Genivar 2010; Hopkins *et al.* 2017). In providing their professional expertise to condo boards, Garfunkel (2017) sees property managers as being an

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inherent part of condominium governance structure. However, Hopkins *et al.* (2017) acknowledge that not all property management firms are the same, ranging from those that make little effort to promote sustainability to those that are proactive in identifying and advocating for sustainability. Ng (2019b) determined that perception of active engagement by property managers in recycling promotion had a significant positive effect on self-reported recycling frequency by residents in MRBs. Katzev *et al.* (1993) also found that those who perceived strong management support for the recycling program were more likely to participate. However, Dello (2019) cautions that poor relations between property managers and residents arising from non-waste-related issues, such as longstanding repair backlogs in the building, can have a negative impact on a waste diversion program.

The presence of communal facilities in MRBs poses a challenge for managing their use. Altmann *et al.* (2018) discuss this challenge in the context of energy and water consumption, noting that when physical infrastructure and billing systems for energy and water are centralized, residents cannot tell how much they are consuming. Although some residents may try to conserve for altruistic reasons, others have little incentive to reduce their water or energy consumption when the cost of use is independent of usage. A similar problem arises with waste diversion.

Since waste collection in MRBs is centralized, it is not feasible to charge individual households for waste collection, only the building. Charging households for use of a waste collection service by volume or by weight (known as pay-as-you-throw—PAYT) rather than by a flat fee has been shown to decrease waste collection quantities significantly, at least in the single-family homes where it has been studied (Lakhan 2016b; Sidique *et al.* 2010; Kinnaman & Fullerton 2000). In the case of MRBs, the property manager and board of directors rather than the householder sees the bill and selects the number of bins made available for residents to use. There is little feedback to individual residents about how much waste they are producing or what it costs, other than information about how much the building is paying.

Another communal facility problem is that building residents using communal waste disposal areas in MRBs are unlikely to be observed by their neighbors when using the facilities, and vice versa. They can put recycling or organics in the garbage bin or leave unflattened cardboard boxes in the waste room without being concerned about judgement from their neighbors (Lakhan 2016a). Visibility of one's recycling practices by others has been shown to be a significant positive factor influencing waste sorting (Bucciol *et al.* 2019) and that lack of visibility can contribute to low diversion rates in MRBs.

In summary, research about the importance of convenience for multi-residential diversion is mixed. Studies on the effectiveness of P&E find that it can increase the quantity of recycling and reduce contamination in MRBs. In-suite space constraints, bin availability, the absence of PAYT and lack of visibility inhibit diversion, while property managers can play key roles in supporting diversion. The significance of each of these factors will be explored in the case study.

3. METHODS

Two methods were employed for researching the case study. The first consisted of a review of climate change and waste-related City of Toronto documents, including plans, research studies, committee reports, standards, and statistics over the last 15 years. The second method was primary data collection using interviews and focus groups. The data collection was part of a larger study on waste diversion in MRBs that was a collaboration between the Toronto Environmental Alliance (TEA), a nongovernmental organization (NGO), and researchers at the University of Toronto. The objective of the study was to test the effectiveness of a building team approach to waste diversion. TEA recruited buildings and helped form a building waste management team tasked with creating and implementing a waste diversion action plan for each building. All teams included the property manager and at least one staff member. Most teams included at least one resident volunteer who was typically a member of one of the building's committees, usually the green committee. Two teams included 3Rs ambassadors, who are resident volunteers trained in

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waste diversion P&E by City of Toronto staff, and two teams included a liaison member from the building's board of directors.

A total of 15 MRBs were recruited for the study and baseline interviews with building team members were conducted between 2018 and 2019. The buildings were of varying sizes, in different areas of Toronto, and with a mix of demographics. Four of the buildings were considered 'model' buildings with high diversion rates. All buildings were condominiums or cooperative housing. Just over one-quarter of households in the City of Toronto live in condominiums (City of Toronto 2020a), with an additional 1.5% living in cooperatives (CHFT 2022). The buildings selected had five or more storeys (so that residents are using a chute and a centralized waste facility, typically on the ground floor or in the basement) and a single waste chute (not a tri-sorter or multiple chutes, which would be more convenient for waste diversion than a single chute). In addition, they all had waste collection services provided by the city, as opposed to securing waste services from a private contractor (so that they all had access to the city's diversion programs).

Data were collected by means of focus groups and semi-structured interviews. The focus groups included two to five people, who were all members of the building's waste reduction action team, for a total of 35 participants. Two buildings did not have focus groups due to scheduling issues. Topics covered during the focus groups included current waste diversion initiatives in the building, successes and challenges with waste diversion, education programs, monitoring and feedback on sorting practices, and contamination problems.

The semi-structured interviews (n = 47) followed the focus groups, covering very similar topics but allowing for more probing on the answers provided. All buildings were represented in the interviews. The interview and focus group recordings were transcribed and analysed for themes using hand coding. Themes were developed both deductively from the existing literature about factors influencing diversion in MRBs and inductively from the data. The coding was reviewed for consistency by at least one other person on the research team. All participants in the focus groups and interviews were granted anonymity and we therefore report any quotations from the interviews using pseudonyms. Quotations were chosen to be representative of a common sentiment expressed by participants.

4. TORONTO CONTEXT

Like Canada, waste-related GHG emissions for Toronto are relatively small but still significant. They are almost entirely landfill emissions and accounted for 7% of community-wide emissions in 2019 (City of Toronto 2021b). Toronto's GHG inventory includes emissions from both publicly and privately managed waste disposal. Emissions associated with privately managed waste are rough estimates since the data are proprietary and there are no requirements for the private sector to report data to the city or province. Emissions from recycling are not included in the inventory and there are no emissions from waste incineration because the city does not have an incinerator.

The city's climate change plan, TransformTO, set ambitious goals for reducing GHG emissions (City of Toronto 2021a). The 2019 inventory found that landfill waste emissions have declined by 75% compared with 1990 levels, exceeding the city's 2030 reduction target. However, it is not clear how much of the reduction is due to a decrease in waste sent to landfill and how much is from implementation of landfill gas capture technologies. TransformTO also includes residential waste diversion targets of 70% diversion by 2030 and 95% diversion by 2050 (City of Toronto 2021a). Residential waste diversion in Ontario is calculated as the percentage, by weight, of waste generated in the home that is not disposed in landfill or incinerated.

Overall residential waste diversion has been stagnant in the city for the last 10 years, plateauing at just over 50% (Figure 1). Of that percentage, about two-thirds is due to organics diversion and the remainder to recycling (City of Toronto 2022a). The diversion rate does not include the contribution of reuse, such as through second-hand markets, for which there are no publicly available data.

The gap between single-family and multi-residential diversion has remained fairly constant during the last 10 years, ranging between 36 and 42 percentage points. The gradual increase in multi-residential diversion between 2008 and 2015 has been attributed to several factors, including the introduction of volume-based fees for garbage collection from MRBs that year, the phase-in of organics collection starting in 2009, and the introduction of four new materials collected for recycling: polystyrene, plastic shopping bags, mixed rigid plastics, and plastic film (Dello 2016).

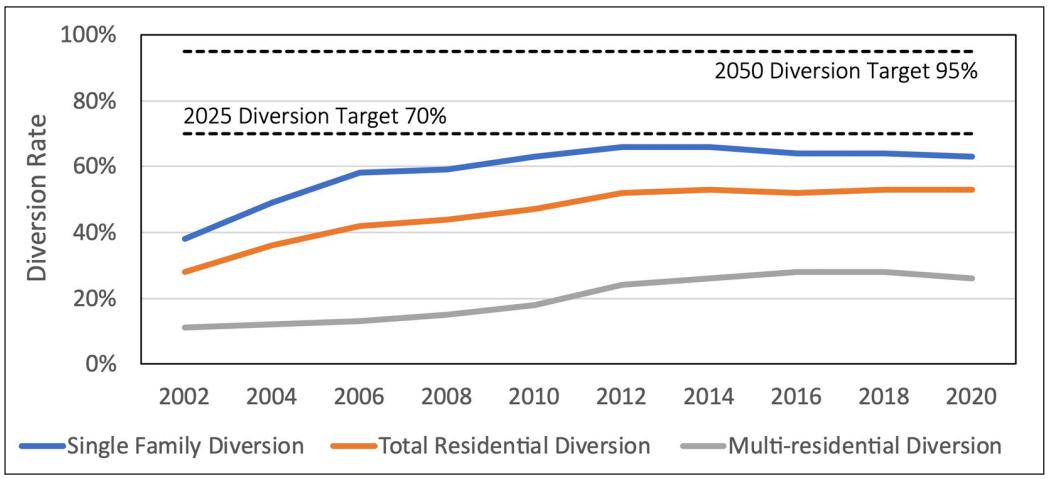

Figure 1: City of Toronto residential waste diversion rates, 2002–20.

City staff and outside experts ascribe a good deal of the leveling off of diversion over the past decade and before that to the 'evolving tonne' (City of Toronto 2016, 2021a; Morawski *et al.* 2015; Kelleher 2015/16). The composition of a tonne of waste has been changing over time. One of the most important reasons for the change is the light-weighting of packaging, with lighter plastics replacing glass, metal, and heavier plastics. A second change is increasing levels of contamination in the recycling stream due to the introduction of new packaging materials that cannot be recycled, such as certain types of plastics and multi-material items. Increasing contamination means that more recycling loads are being rejected by buyers and sent instead to landfill.

In recognition of the evolving tonne, some municipalities have expressed dissatisfaction with the weight-based diversion rate as a metric for waste system performance (Morawski *et al.* 2015) and are exploring alternative metrics. Researchers and other levels of government are actively exploring alternative metrics as well, specifically those that are impact based rather than weight based (Salemdeeb *et al.* 2022). Toronto staff have proposed several alternatives, including GHG avoidance per tonne of waste diverted from landfill (City of Toronto 2022a), but the city is still using waste diversion as its primary metric and the most recent provincial waste policies emphasize waste diversion rates as well (Government of Ontario 2017, 2020).

It is important to note that the amount of diversion reported for MRBs in Figure 1 is for those serviced by the City of Toronto only, comprising about two-thirds of the city's MRB stock (City of Toronto 2016). The province of Ontario mandates that both publicly and privately serviced MRBs have diversion programs for recycling, while organics diversion becomes mandatory in 2025 (Government of Ontario 2018). Since the City of Toronto requires organics diversion programs in the buildings it services, but organics diversion is currently voluntary in buildings with private collection, waste diversion is likely considerably lower in privately serviced buildings than the rates shown in Figure 1.

5. WASTE DIVERSION CHALLENGES AND RESPONSES: CITY LEVEL

The City of Toronto has responded to diversion challenges in numerous ways to improve multi-residential waste diversion. This section examines the main actions taken by the city, organized according to the three modes of governing. Where possible, the effectiveness of the action is assessed using our interviews, City of Toronto data or research reports, or relevant research from other sources. Three issues raised in the literature review arose during this part of the research, namely the issues of convenience, space constraints in suites, and P&E programs.

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5.1 CITY: GOVERNING BY AUTHORITY

The City of Toronto has used regulatory tools, in the form of building standards, and sanctioning tools, in the form of fines, to incentivize waste diversion. Building standards target infrastructure effectiveness while sanctioning focuses on reducing contamination of recycling streams. Regarding building infrastructure, city reports (City of Toronto 2010) and participants in the interviews and focus groups all highlight that infrastructure in Toronto's older stock of buildings makes it more convenient to dispose of garbage than recycle or divert organics. Voluntary and mandatory building standards for new multi-family developments are being used in several jurisdictions to address the infrastructure problem. For example, New York City requires that new buildings have one chute for garbage and one chute for recycling, or a single chute with a bi-sorter, or a single chute with space in the chute room for recycling bins (New York City 2014). New buildings in Hong Kong must have waste rooms on each floor with sufficient space to accommodate four bins for different recycling streams plus a garbage bin or chute (Yau 2012). Recent guidance for new developments in San Francisco specifies that if a building has a chute system it must consist of separate chutes for garbage, recycling, and organics (Cascadia Consulting Group 2021). Similarly, Richmond Hill, Ontario, requires three chutes in new developments (City of Richmond Hill 2019).

In 2010, the City of Toronto introduced a standard for new developments, known as the Green Standard, that is part mandatory and part voluntary (City of Toronto 2022b). The standard covers a range of environmental issues, including waste, and has two levels: a mandatory Tier 1 level and the voluntary Tier 2 level. Meeting Tier 2 requirements earns applicants a reduction in their development charges. A key element of the Tier 1 conditions is that buildings must make waste diversion as convenient as waste disposal by installing either a single chute with a tri-sorter, two separate chutes with one being a bi-sorter, three separate chutes, or, in the absence of any chutes, install a central waste collection and diversion facility on the ground floor or basement. Tri- and bi-sorter chute systems have a single chute with a mechanism at the bottom that automatically sends waste coming down the chute to one of three (tri-sorter) or two (bi-sorter) bins. The destination bin is chosen by the resident pushing a button on a control panel in the chute room. Residents must wait to use the chute for a particular waste stream, such as recycling, if residents on another floor are using it for another waste stream, such as garbage. Other Tier 1 conditions include minimum space requirements in the building for a waste storage room and for storage of bulky waste, household hazardous waste, and electronic waste.

Although the Tier 1 standard aims to make waste diversion as convenient as garbage disposal, little research has demonstrated that the proposed chute designs are better than a single garbage chute with centralized recycling and organics diversion. Lakhan (2016a) studied a two-chute design and found that recycling diversion quantities increased only slightly, but so did contamination, when multi-family buildings were retrofitted to add a recycling chute to each floor. This was despite an extensive campaign by property managers to promote the use of the recycling chutes. Three studies have looked at the effectiveness of tri-sorters. In their study of 14 multi-family buildings, Genivar (2011) found that tri-sorters produced high levels of contamination along with frequent mechanical failures, forcing some property managers to use the tri-sorter as a single combined waste chute system. The problem was most severe in tri-sorters without lockable chute doors that prevent the mixing of waste streams. Dello (2019) discovered that tri-sorter condominium buildings had about the same diversion rates as condominiums with a single garbage chute, but the contamination rate for recyclables was higher for single-chute buildings. Miflin *et al.* (2017) presented case studies of five buildings in New York City, each with a different waste infrastructure, and found that compared with a single chute system, the tri-sorter chute required more frequent maintenance. We are not aware of any research on the effectiveness of a three-chute system, although this system seems the most promising in terms of ease of use.

The Green Standard's Tier 2 condition specifies that new buildings must have cabinet space in all kitchen suites for the segregated collection of recyclables, organics, and garbage. Several participants in our study complained about the lack of space for storing recycling and food waste bins in suites.

> [...] my kitchen's not very big. So, I really don't have a place for it. But I have a place for the other, you know for regular garbage and so, you know, some of my banana peels, which would probably make great compost, right, are going out in my garbage right now.
>
> (Naomi, co-op resident)

Despite expressing an attitude supportive of composting, this resident is unable to divert because of infrastructure constraints. The Tier 2 requirement may help address in-suite storage in future, but since it is currently a voluntary standard, not all new buildings will include it.

Sanctioning authority in Toronto takes the form of fines for too much contamination of the recycling stream. A load of recycling that is too heavily contaminated with non-recyclables decreases the effective diversion rate because it has to be sent to landfill. Toronto introduced recycling bin inspections for MRBs in 2016 to try to address the problem (City of Toronto 2018). If there is too much contamination, inspectors classify the bin as garbage and the building must pay a garbage collection fee for the recycling bin. The additional garbage fee is equivalent to a fine for contamination.

5.2 CITY: GOVERNING BY PROVISION

The most significant service change introduced by the City of Toronto to date has been to roll out a mandatory multi-residential organics collection program. The program is one of the main reasons that diversion rates have increased in MRBs since 2009 (Dello 2019).

In 2009, the city started providing MRBs with blue reusable bags that residents could use for storage and transportation of recyclables. It also started offering small counter-top bins, known as kitchen catchers, for storing organic waste. Both are provided free of charge to a building if property managers request them. Although there have been no assessments of the effectiveness of these two measures for Toronto MRBs, Bernstad (2014) studied a system for MRB in-suite organics storage in Sweden. Instead of kitchen catchers, each suite had a metal frame installed under the sink for storing organic waste in paper bags. The amount of organic waste collected per household increased substantially after installation and sorting accuracy improved as well. Bernstad suggests that presence of the frame may be acting as a nudge for residents to separate food waste every time the under-sink cabinet is opened.

5.3 CITY: GOVERNING BY ENABLING

An important enabling tool has been the introduction of financial incentives to reduce waste in the form of a PAYT system for waste collection charges. Although PAYT may not have the same impact for MRBs as it does with single-family homes, the cost of multi-residential PAYT fees can be considerable and may influence diversion efforts. The City of Toronto has a volume-based multi-residential fee system that it phased in over several years, and the impact of that system came up numerous times during the interviews. For example, a co-op board member commented that:

> Ten years ago, we were paying five thousand dollars a year for waste management. Now we're paying thirty-six thousand dollars a year. [...] So, you know, because they were discounting it for a number of years and now, they're reflecting in the bills what the true cost of waste management is. [...] Seven times what we were paying ten years ago is a lot of money. You know the only way to reduce it is to get more into the blue and the green and less into the brown.
>
> (John, co-op board member)

The fees therefore served to incentivize efforts within the building to reduce collection costs of 'the brown' or garbage by increasing use of the blue bins for recycling and green bins for organics. We heard similar comments from property managers, staff, and green team members. However, a few property managers commented that waste fees are not as strong a motivation for change as other costs in their annual budget, such as energy costs. One property manager from a building that had implemented some successful waste diversion initiatives tried to use a financial argument to persuade another building to do the same, but found that:

> the financial aspect is not enough, because talking to my building up the street again, we talked about my experience here and what they looked at is the numbers. They said even if we can reduce our waste by twenty percent, that's two grand a year in a multimillion-dollar budget. No motivation.
>
> (Zara, condo property manager)

The city offers MRBs several P&E services aimed at reducing contamination, including stickers, posters, site visits, 3Rs ambassador training, and a tenant engagement guide for use by property managers or resident leaders (City of Toronto 2017). Despite efforts to step up education programs and inspections, city-wide recycling contamination rates in Toronto for single-family and multi-residential combined have been increasing steadily, from 22% in 2015 to 30% in 2019 (Yazer 2020). A four-season waste audit of five MRBs in 2017–18 found an even higher contamination rate of 37% (Dello 2019). The most common contaminants are organic waste, bulky items, textiles, and black plastics (City of Toronto 2018). In an assessment of the state of the city's diversion system in 2018, city staff attributed the rise in contamination to several factors, including lack of knowledge about the impacts of incorrect sorting, confusion when residents see that adjacent municipalities accept items that Toronto does not, and lack of knowledge about correct sorting practices, particularly for problematic items, such as multi-material packaging (City of Toronto 2018).

The interviews confirmed that a great deal of confusion exists among residents about whether items go in the recycling, garbage, or organics bin. Sorting destinations for waste items depend on whether the item is accepted by the city's recycling or organics program. In some cases, part of an item, such as the lid or sleeve on a take-out coffee cup, is recyclable, while another part, such as the cup itself, is not (City of Toronto n.d. b). Toronto's Waste Wizard, an online tool developed by the city for checking where a waste item goes, provides sorting instructions for over 2000 items (City of Toronto n.d. b), suggesting the complexity of the sorting task. As one resident commented:

> I think people still are confused about the rules of what's recyclable. [...] That's because I still observe and or know from people that are like, oh, the rules. Plastic. Not that kind of plastic. This plastic. Oh, no, that's black plastic. Some people get confused about that still and rightfully so. I mean, it's a bit of a list to learn.
>
> (Ayesha, co-op resident)

Plastics are particularly challenging since some types are not accepted in the Toronto system. For example, black plastics are not allowed but all other colors are. Uncertainty about what goes where can be frustrating to residents and result in unintentional contamination. As one staff member noted:

> I found that when people did throw things out that they shouldn't, it was not because they didn't care, it was they didn't know.
>
> (Jeff, co-op staff member)

Residents may also end up 'wishcycling' or sending an item to recycling because they wished it would go there when in fact it does not (Ikiz *et al.* 2021).

6. WASTE DIVERSION CHALLENGES AND RESPONSES: THE BUILDING LEVEL

This section reports on the challenges faced and responses made by buildings to support waste diversion through different modes of governing. As revealed during the interviews and focus groups, buildings were dealing with four challenges identified in the literature review, namely convenience, P&E, and overflowing bin and waste rooms that were poorly designed.

6.1 BUILDINGS: GOVERNING BY AUTHORITY

A couple of buildings in the study had enacted rules allowing them to fine residents when staff observed obvious contamination, such as black garbage bags in the recycling bin or uncrushed

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boxes stuck in the chute. Staff members in MRBs play a key role in facilitating increased diversion and reduced contamination. They see contamination in the waste stream on a daily basis and are the first to learn when the city rejects a recycling load for too much contamination. Staff members reported monitoring contamination levels and trying to correct them, either by pulling out incorrectly sorted items from the recycling or providing feedback to residents. The difficulty with feedback was in trying to identify the offenders since resident use of waste chutes and waste rooms was usually not visible to others. Repeat offenders would be given a warning by the board and could eventually be fined. However, the two buildings with fine mechanisms reported that fines were rare because direct feedback and warnings were usually sufficient. One participant from another building was skeptical about the potential use of fines because they did not believe that condominiums had the legal authority to fine their residents.

6.2 BUILDINGS: GOVERNING BY PROVISION

One concern raised constantly by participants was the inconvenience of recycling and organics bin locations. All buildings had a single waste chute intended for garbage disposal, and while some had space indoors—usually the ground floor or basement—for recycling or organics collection, others had organics and recycling bins outdoors. One building had organics (green) bins in the chute rooms. The property manager of that building commented that:

> In my other building, we don't provide them with a green bin [in the chute room], and they have to take it outside. So, they don't even bother, it goes down the chute.
>
> (Alison, co-op property manager)

Having small organics bins and recycling bins in the chute room is an ideal solution for increasing convenience, but participants noted that chute rooms were usually too small for bins or that fire codes often prohibited bins in the room.

In order to increase infrastructure convenience, two of the buildings in the study received approval from their boards to convert their garbage chutes to organics chutes and shift garbage disposal to the basement. They chose organics for the chute because waste audits have shown that organics typically comprise over one-third of the garbage stream in MRBs that have organics diversion programs (Dello 2016; AET 2021) and are therefore worth prioritizing for recovery. Another consideration was the 'ickiness' of having to carry an organics bag one, two, or more times per week (depending on household size) through hallways and elevators to the basement or outside. In both buildings, the conversion was well-received and led to increased diversion and reduced garbage collection costs.

> You know what people thought [about the chute conversion]? 'This was a great idea!' They loved being able to get rid of food waste any day of the week. It's a walk down the hall to get rid of [...] you could do it two or three times a day if you are baking, or cooking or whatever, that often right? Because it's right at the end of your hallway. It's more convenient to get rid of the smelly stuff [laughs].
>
> (Jennifer, condo 3Rs ambassador)

However, in one building that was considering conversion, a few residents objected. They were concerned about the accessibility of the garbage bins and about possible odors in the chute rooms. Despite the pushback, the building's board went ahead with the conversion of the chute with support from the majority of residents and with measures in place to help those with accessibility issues. The city has not performed any waste audits to determine whether a single organics chute results in more or less contamination of the organics stream by recycling and garbage, but both buildings that have converted had significant reductions in the amount of garbage collected, with one reporting a decrease of C$60,000 in garbage fees per year.

MRBs do have one notable infrastructure advantage over single-family homes in that they can offer collective resources that make diversion more convenient, assuming they have available storage space. Most of the buildings in the study had one or more of these resources on-site: donation bins for clothing and household items, a reuse shelf or table where residents can bring reusable items

to give away, and bins for collection of batteries, household hazardous waste, pharmaceuticals, beverage container deposit-returns (with the proceeds going towards building events), paint, light bulbs, and e-waste. The city does not require any of these for existing buildings, but the Toronto Green Standard specifies that new buildings must have space for collection of bulky waste, household hazardous waste and electronic waste. The city provides a free service, known as the Toxic Taxi, that collects household hazardous waste from MRBs on demand (City of Toronto 2015). Many of the study participants we spoke with were unaware of this service.

6.3 BUILDINGS: GOVERNING BY ENABLING

Participants stressed the need for 'education, education, education' (Lena, condo green committee member) to inform residents about correct sorting. They also remarked on the challenge of delivering education in multiple languages:

> We've got over 27 different languages in the building so, [laughs …] we always hope that what happens is that you get a flyer, and the family will tell them, or one of the neighbors that speaks the same language will tell them.
>
> (Clara, co-op green committee member)

Language can be a significant barrier to communicating about waste diversion in Toronto because it is a highly multicultural city. A language other than English is the mother tongue for approximately half of the population (City of Toronto 2022c). The city has recycling and organics posters in up to 18 languages (City of Toronto n.d. a), but finding a way to deliver these to residents can be challenging, as noted in the example above. We found that in many buildings property managers and resident leaders were not aware of the available materials, or were not sure how to order them.

Overflowing recycling bins were frequently mentioned as an issue that can reduce the diversion potential of a building, as were accessibility issues in the waste room.

> So, we think that part of the problem with the recycling is they get like, overflowing and then people throw recyclables down the garbage. Or […] it's like too hard for them to reach the garbage cause the way the recycling is, recycling first and then garbage, so maybe that's why they're dumping some of the garbage in there too.
>
> (Sofia, condo 3Rs ambassador)

Lack of capacity in the recycling bins leads to recycling ending up in garbage while a poorly designed configuration of bins in the waste room with the garbage bins at the back leads to garbage ending up in recycling bins. The first problem could be resolved by ordering more recycling bins, if there is sufficient space to accommodate them, while the second would require shifting bins around in the waste room. Both solutions would be at the initiative of in-building actors, such as property managers or resident leaders rather than the city, although the city encourages resolution of these problems with its garbage fee and fine systems, respectively.

7. DISCUSSION AND CONCLUSIONS

Both the municipality and buildings were found to be using all three modes of governing in support of waste diversion. Some of the responses to challenges within each mode, such as chute conversion and fines have not been discussed elsewhere in the literature.

The case study illustrates multiple ways in which problem identification and problem-solving must come from decision-making and actions within buildings rather than just through municipal programs or policies. Examples range from freshening up the waste room to make it more welcoming and bins more accessible, deciding when more recycling or organics bins are needed, to organizing a new service such as a reuse shelf. The question is how to support or incentivize those types of decisions.

One caveat on the effectiveness of incentives is that incentives that work for single-family homes may not work as well for communal facilities in multi-residential buildings (MRBs). For example, pay-as-you-throw (PAYT) for waste collection in MRBs is only possible at the collective, building

level rather than at the individual level. Major utility upgrades or modifications, such as converting a garbage chute to organics, is a collective decision rather than an individual decision and it may not be possible to garner sufficient support among residents to make the change. In single-family homes where there is curbside collection of recycling and organics, setting out one's boxes or bins is visible to neighbors, unlike in MRBs, and high visibility has been shown to support waste sorting. Examples of all three issues were provided in the paper.

If current multi-residential waste diversion trends continue, it is highly unlikely that Toronto will meet its target of diverting 70% of waste from landfill by 2030. Single-family diversion is close to that target, so it just needs a slight push upward to meet it. However, multi-residential diversion will need to increase by almost 50 percentage points to reach the target.

Several actions are recommended for improving multi-residential waste diversion in Toronto and for other municipalities facing similar waste diversion deficits. The first action, which might help a great deal in increasing organics diversion in the older building stock, is to convert a garbage chute to an organics chute. This action is particularly appropriate for municipalities that ban in-sink food waste disposal units (garburators) because of the negative impacts on their wastewater treatment systems and on water consumption (McKenzie 2012). However, before being promoted widely, chute conversion would benefit from careful research into its effectiveness and the implications for garbage bin accessibility for the mobility-impaired. A second action that would benefit from additional research is the development of new construction standards for chute design since there is some question about the waste diversion effectiveness of mechanical sorting systems, such as tri-sorters, that are being promoted by current standards.

Another action worth considering comes from Dello (2019), who observed that property managers in Toronto currently have no obligation to refresh or maintain posted instructions about diversion. She suggested that collection service agreements between municipalities and MRBs should include a clause requiring managers or owners to post and regularly update promotion and education (P&E) material. The City of Toronto recently moved in this direction by introducing a bylaw for purpose-built rental buildings requiring that buildings have recycling information posted, or be fined (City of Toronto 2020b). However, it is not yet applicable to condos or co-ops and the bylaw does not specify that information should be in multiple languages or use clear visual images for those not fluent in English. Cities with similar P&E requirements include San Francisco and Chicago, which have ordinances that fine building owners, regardless of ownership type, if they fail to educate residents about waste diversion (Knickmeyer 2020). Like Toronto, neither city specifies what the education program should look like.

One element of an education program could be to ensure that new residents receive a welcome package that includes instructions about sorting and waste management in the building. For example, the City of Calgary, Alberta, has a bylaw to this effect (City of Calgary 2022). Welcome packages could also highlight the economic incentive for diversion, emphasizing how condo or co-op fees can be reduced when everyone does their part in recycling and diverting organics.

Representatives from several of the buildings in the study mentioned that they would like to have been able to offer a wider range of diversion programs on site, such as reuse tables, but were unable to do so because of space constraints for storing recyclable or reusable items. Municipal green building standards for new construction could address this problem by including sufficient indoor space requirements to accommodate expanded services on site. Even better would be if the spaces were sized to anticipate future diversion programs, such as diversion streams for textiles or multi-stream recycling bins.

New construction standards such as the Toronto Green Standard normally do not cover ongoing building operations. Municipalities considering ongoing standards for waste diversion could look in the first place to voluntary green building programs with waste diversion requirements. For example, the voluntary Leadership in Energy and Environmental Design for Operations and Maintenance (LEED O+M) (2018) rating system identifies a diversion target that buildings must meet in order to receive LEED certification credits. Eisenstein *et al.* (2017) studied an early version of LEED O+M with waste diversion requirements and found that the average waste diversion rate

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for certified office buildings was 53% compared with 7% for conventional buildings. However, a cautionary note about voluntary certification programs is that the standards may not be as rigorous as a municipality might want and, if so, their use should be considered an interim measure before developing operations standards tailored for the municipality.

One challenge not mentioned in the multi-residential literature, perhaps because it is not specific to MRBs, is the complexity of packaging and how that complexity can lead to contamination when packaging is sorted incorrectly by residents. Packaging complexity is not a problem that can be resolved at the local level but rather one which requires provincial or federal intervention. Provinces in Canada establish waste reduction policies and programs, while the federal government can ban products and packaging that are toxic for the environment. The municipal role in achieving changes in packaging lies primarily in advocacy with upper levels of government.

Provincial intervention is due to arrive in Toronto in 2023 with the phase-in of Ontario's new extended producer responsibility (EPR) program for packaging and printed paper. EPR programs are now widespread and require producers to take responsibility for end-of-life (EOL) management of the products (and product packaging) that they sell and transfer the cost of EOL management from municipal taxpayers to producers. EPR is also meant to encourage producers to invest in 'design for environment', such as designing their products for recyclability or disassembly, in order to reduce waste disposal costs (OECD 2016; Pouikli 2020). However, the extent to which the design for environment goal has been achieved with EPR programs to date is debatable (Sanz *et al.* 2015; Joltreau 2022; OECD 2016).

Ontario already has a partial EPR program for packaging and printed paper, where municipalities operate the diversion program and producers pay municipalities for about half the collection and processing costs that they incur. The new model, known as full EPR, will require producers to operate and pay all the collection and processing costs (City of Toronto 2020c). One concern expressed by environmental groups, however, is that the new Ontario program has low diversion targets for specific materials and poor monitoring requirements (Environmental Defence *et al.* 2021), which could negatively affect future diversion rates.

The federal government is undertaking a number of actions to address complexity and confusion around plastics, some of which will directly impact recycling practices. Phasing in from December 2022 to 2025, Canada will impose a ban on the import, manufacture, and sale of six single-use plastic items (bags, utensils, stir sticks, some foodware, six-pack rings, and straws) (Government of Canada 2021). Additionally, the federal government is developing regulations for 'recyclable' labelling on any plastic package or single-use product. The 'recyclable' label will only be applied if 80% of Canada's recycling facilities accept, and have reliable end markets for, those products (Government of Canada 2022).

A final recommended action for municipalities is to consider additional metrics for measuring waste system performance, given the weaknesses of the widely used, weight-based diversion metric. The policy implications of using a metric that captures the impact of waste diversion on greenhouse gas (GHG) emissions can be quite different from those that use waste diversion alone (Greene & Tonjes 2014). One study that examined not only GHG emissions from EOL management of materials (via recycling, incineration, and landfilling) but also life cycle emissions associated with their consumption found that consumption of materials produced approximately 10 times more GHG emissions than EOL management (Anshassi *et al.* 2021). The results suggest that local governments committed to GHG reductions may want to focus as much attention on actions before EOL management, such as encouraging reuse or preventing the generation of waste, as they do on those that divert waste from landfill.

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COMPETING INTERESTS

The authors have no competing interests to declare.

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