The Future of Trash

Waste Containerization Models and Viability in New York City

sanitation

April 2023

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Letter from the Commissioner

Fellow New Yorkers,

Cities in Europe, Asia, and South America have spent the past 15 years innovating around how they handle waste, moving to containerize much of it prior to collection. New York City, however, has not even studied it. It is time for us to change that.

As part of the Adams Administration's commitment to long-term strategic planning that improves quality of life and creates an equitable, healthy, and resilient future, the New York City Department of Sanitation has spent the past six months studying the viability of waste containerization in New York City. This complex work included surveying best practices from dozens of peer cities across the globe, building a detailed model of waste generation in tonnage and volume at the block level, and performing analysis of market conditions for new fleet and equipment that would be required to make containerization a reality. This report is the distillation of the work that was performed by a cross-functional team from across the Department of Sanitation with support from peers in government and outside consultants.

In short, waste containerization *is feasible* in many parts of New York City. Like many good things, it will not come easily, but there is no doubt that it can be done.

This report is the beginning, not the end. We will need to continue to build on the foundation of this report and test, in practice, how any waste containerization solution affects DSNY’s operations, public spaces, communities, and New Yorkers. Citywide waste containerization requires extensive changes to our City’s streets and public spaces – potentially some of the largest changes in a generation.

New Yorkers deserve clean, safe, and vibrant neighborhood streets. We deserve the best waste management system in the world, but it has to be done right. This report is the first serious step toward that goal.

Jessica Tisch
Commissioner, New York City Department of Sanitation

Acknowledgements

This report was prepared by the New York City Department of Sanitation. The report draws from the Department's decades of experience collecting and processing 24 million pounds of refuse, recycling, and compostable material in New York City daily. The drafting of this report was a collaborative effort that required hundreds of hours of work by an interdisciplinary group of civilian and uniform DSNY personnel.

DSNY's report team was led by Francesca Haass, Gregory Anderson, and Neil Eisenberg.

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This report relied on significant support from the New York City Department of Transportation and McKinsey & Company. It was informed by the work published in the Adams Administration's 2023 *PlaNYC: Getting Sustainability Done,* as well as decades of research conducted by advocates and information provided by public servants working in cities around the world.

Executive Summary

This report is the outcome of a detailed study of New York City's waste generation, collection operations, international waste containerization practices, equipment options, and the challenges New York City would face in containerizing its daily waste.

What is Containerization?

For the purposes of this report, containerization is defined as the storage of waste in sealed, rodent-proof receptacles rather than in plastic bags placed directly on the curb. Containerization is intended to mechanize waste collection, reduce the visibility of garbage set out in public spaces, and reduce the presence of vermin.

Municipal containerization models, such as those broadly used across Europe, take different forms depending on density:

- **Individual bins** are optimal in many low-density neighborhoods and provide one set of bins for each customer or waste generator.
- **Shared containers** within close reach of all residential addresses are appropriate in higher-density neighborhoods. Shared containers may be wheeled or stationary, and are commonly standardized in size, shape, and color.

Cities across Europe use a combination of both individual bins and shared containers to meet their residents' containerization needs. Many cite Barcelona as the pinnacle of waste containerization, with a fleet of uniform, omnipresent shared containers on every residential block. In fact, Barcelona uses both shared containers and individual bins of various types: hoist-lifted, side-loaded, and rear-loaded. This multifaceted approach is common in cities with containerized waste collection, reflecting the varying needs and physical characteristics of each neighborhood.

In this report, containerization refers to the use of individual bins and shared containers, following this international model.

Key Challenges

Waste containerization is rarely as simple as placing large dumpsters on the street and hoping residents use them properly. There are important considerations around design, operations, infrastructure, reliability, and human behavior, each of which adds a level of complexity to an already challenging proposition.

Some cities have had containers overflow with trash, either on a routine basis as in Rome, or as the result of service disruption, as in the recent Paris garbage strike. Containerization can also create inefficiencies for collection operations, as improperly-placed loose bags may require a separate truck from automated collection trucks, as in Barcelona.

Containerization also highlights the need to appropriately balance the use of space in urban areas – stationary containers occupy curb space that may have been prioritized for other uses. To minimize the number of containers, daily collection is common, such as in Paris and Barcelona.

The implications of these challenges in New York City are illustrated on the next page.

Executive Summary, *cont.*

New York City has a combination of environmental, operational, and built realities that present significant challenges to rolling out shared containers in neighborhoods where they would be most appropriate. The crux of the issue is that the City produces a high volume of waste in a small area, with little-to-no flexibility to build outside of pedestrian and street lanes (e.g., underground, alleys), and substantial competition for curbside space. These challenges can be managed and overcome; this report assesses mitigation strategies used in other cities and provides an appraisal of requisite public space and infrastructure tradeoffs to realize a generational change in the City's management of waste.

Population Density

New York City has nearly 30,000 residents per square mile, producing a far greater volume of trash in a smaller area than other cities.

Built Environment

New York City lacks alleyways or anywhere to "hide" containers and cannot utilize underground space due to decades of complex infrastructure development.

Weather

Snow accumulation presents operational challenges to certain models of mechanized collection of containers.

Curb Space

Substantial space along curb lines is already used for fire hydrants, bus stops, outdoor dining, bike and bus lanes, and parking.

Collection Frequency

To reduce the piles of trash to a volume that can fit in a reasonably-sized shared container, the City would need to double collection frequency in some areas – or more...

Fleet

There is no existing truck able to service shared containers that can be deployed *at scale* in the United States without a lengthy development process.

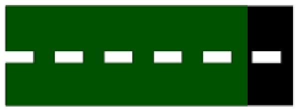
Despite all of these challenges, options for containerization in New York City through both individual bins and shared containers do exist.

Executive Summary, *cont.*

Is Containerization Viable in New York City?

For 80% of residential street segments, containerization is viable without taking more than 25% of available curb space on a given block. With increases in collection frequency or removal of conflicting uses, another 9% of street segments become viable. In total, containerization is viable for 89% of residential street segments comprising 77% of the City's total residential waste output.

89%
of all residential streets

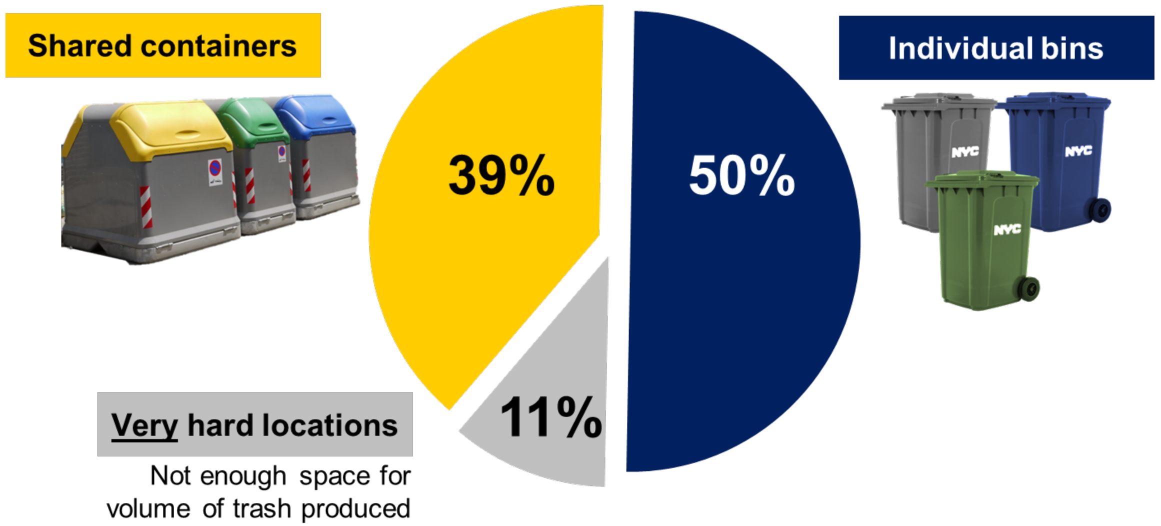


77%
of residential waste tonnage

Up to
10%
of parking spaces on residential streets

This viability assessment was determined through a months-long analysis that, for the first time ever, projected waste generation volumes at the block level to determine the number and sizing of containers that would be needed to service every block in the city.

For shared stationary containers, this means repurposing up to 10% of curb space on blocks with residential buildings – approximately 150,000 parking spaces total. On some blocks, up to 25% of existing curb space would be occupied by containers, but on most blocks, the share would be far lower.



Of the street segments analyzed, 50% would be appropriate for individual bins without eliminating any curb space uses. These include large areas of Staten Island, eastern Queens, southern Brooklyn, and the northern Bronx.

Another 39% of street segments would be appropriate for shared containers. The remaining 11% present containerization challenges – either the amount of waste is too substantial for the length of the street or other immovable restrictions along the curb, such as bus lanes or moving lanes, prohibit the placement of shared containers.

This report details case studies of each of these categories, along with the operational and infrastructure changes required to implement containerization, including the need to build a modern, European-style truck for the American market.

Introduction

Background & Purpose

Mayor Eric Adams has communicated a commitment to a citywide approach to containerization as part of the Administration's ongoing efforts to "Get Stuff Clean."

Although containerization has been part of the public discourse in New York City for the past decade, scant progress had been made until recently. In the past year, DSNY has taken a number of steps to begin to advance containerization in the City.

Among them:

- Encouraging the use of individual bins through changes to setout rules, allowing New Yorkers to set out their trash at 6 pm, rather than 8 pm, if trash is placed in an individual bin;
- Advancing a five-borough pilot of shared containers for both residential and Business Improvement District use;
- Undertaking a study to determine the feasibility, optimal operational model, and design foundations of a citywide approach to containerization via both individual bins and shared containers, with appropriate strategies for both residential and commercial waste.

DSNY is also changing operations to reduce the amount of time that New Yorkers interact with trash bags. More collection than ever has been moved to the midnight shift, particularly in high-density areas, and 4 pm collection – a practice that left 10% of trash on the curb for a full 32 hours – has been eliminated entirely. Additionally, the remaining day shift collection has been moved up to 5 am from 6 am, so that more trash is gone before most New Yorkers wake up.

As outlined in the Mayor's Office of Climate and Environmental Justice's 2023 *PlaNYC: Getting Sustainability Done,* containerization is vital to the Adams Administration's vision for an accessible and connected network of open spaces in New York City.[1]

The goal is clear: cleaner streets, fewer rats, and a more livable City.

The intent of this report is three-fold:

- Survey best practices from international peer cities;
- Assess the viability of waste containerization in New York City, based on a detailed model of waste tonnage and current operational realities;
- Define the immediate next steps.

What is Containerization?

Containerization refers to the storage of waste in sealed, rodent-proof receptacles rather than in plastic bags. It is intended to mechanize waste collection, reduce the visibility of garbage set out in public spaces, and reduce the presence of vermin.

Municipal containerization models may take different forms, depending on density: in many low-density neighborhoods, individual bins are optimal; in mid- to high-density neighborhoods, shared containers within close reach of all residential addresses are appropriate. Shared containers may be wheeled or stationary, and may be standardized in size, shape, and color.

Containerization has been discussed in New York City going back to the 1970s, but never implemented at scale.

Paris, France

Amsterdam, Netherlands

London, England

Why Containerization Matters

Large piles of trash have become part and parcel of the New York City streetscape, and dodging between mountains of 44 million daily pounds of trash is a standard part of a New Yorker's commute. It's everywhere. Bags of trash are left out on curbs the night before pickup, proliferating the presence of rats, causing a public nuisance of trash mountains on sidewalks, and leaving behind a soiled sidewalk long after bags have been picked up. It hasn't always been this way; New Yorkers were required to use bins until the late 1960s[1], and most Cities in the world do not allow trash bags unfettered access to the streets.

New Yorkers are fed up; "dirty street conditions" are consistently in the top 10 service requests received by 311, with over 200,000 requests received in the past year alone.[2]

Rats thrive and reproduce based on access to food, which is typically found within 100 feet of their nest.[3] In New York City, that food source sits in easily-accessible bags two to three times per week in front of every property: nearly 1/3 of all residential waste is made up of food.[4] A study conducted by the New York City Department of Health and Mental Hygiene shows that a high volume of garbage is the top determinant of urban rat presence, and reduction in accessible trash is the single most effective intervention to curb rat populations.[5]

Rats

Pedestrian obstruction

Dirty streets

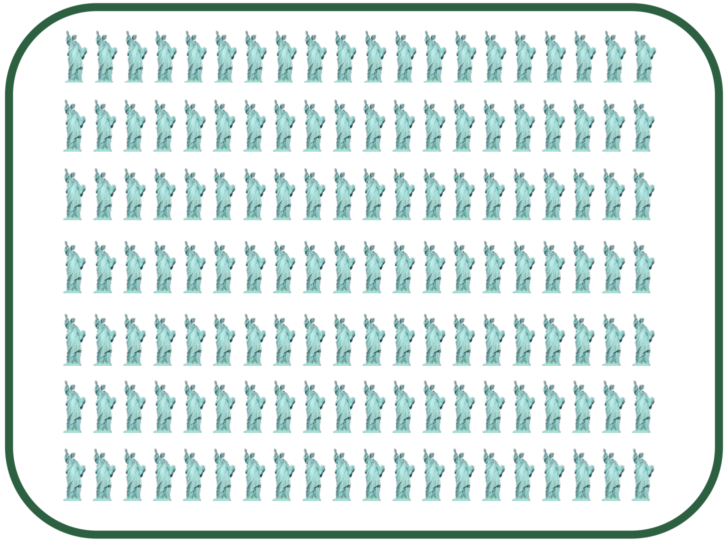
Current State of Trash

By the Numbers

DSNY Collections

New Yorkers leave out 44 MILLION pounds of waste *every day* of service…

…Equal to the weight of 140 Statues of Liberty!



Residential and institutional waste collected by DSNY accounts for 24 million pounds of the overall 44 million pounds of waste left on New York City curbs each day.[1] This waste is generated by 3.5 million households in the five boroughs, as well as from 1,400 public school buildings, government institutions (including public hospitals), and many non-profit institutions. The balance is commercial waste that is collected separately by the private carting industry.

24 million
pounds of daily waste

1 million
residential properties

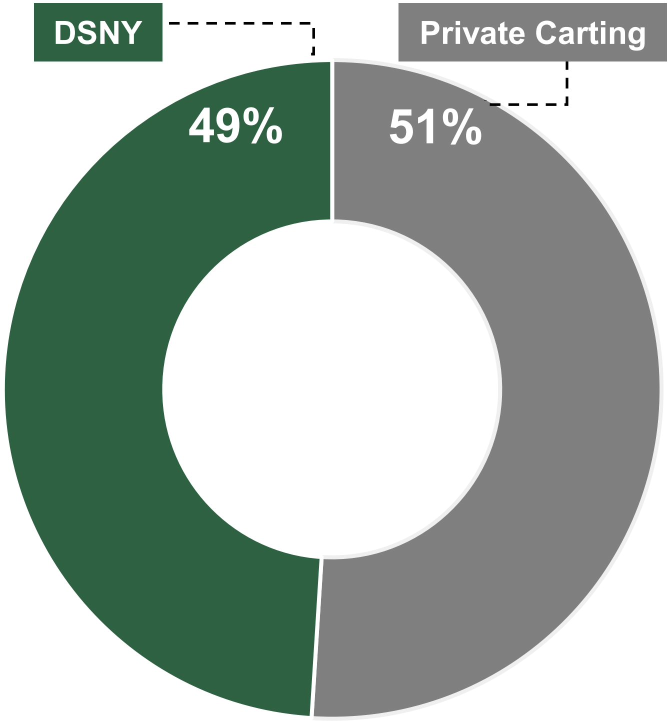
1,400
public school buildings

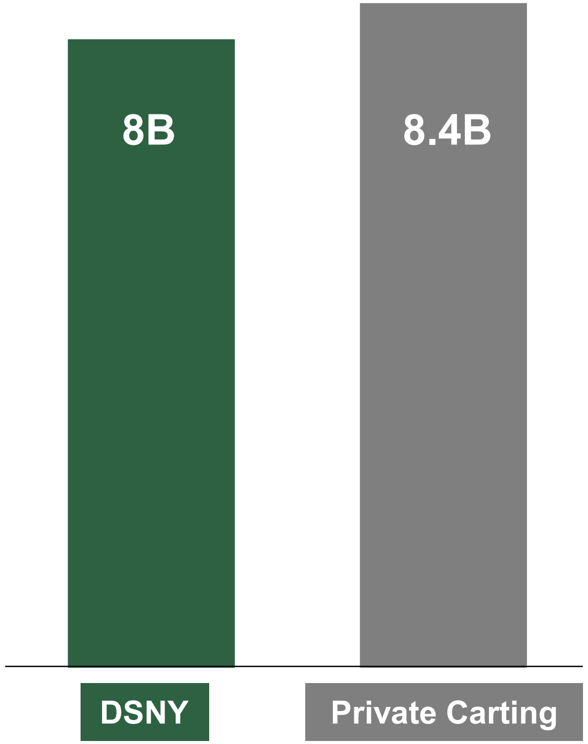
7,200
weekly collection routes

610
collection zones

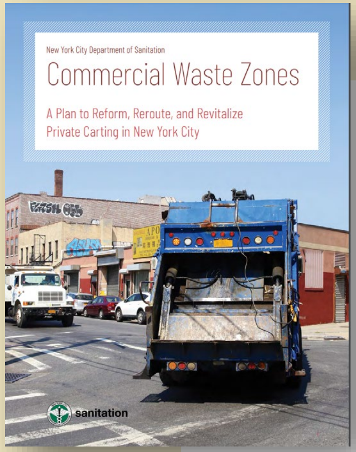
Commercial Collections

Commercial waste represents more than half of the annual waste generated in New York City. Each year, more than 100,000 commercial establishments generate approximately eight billion pounds of waste.[1]





Approximately 90 private carters collect all commercial waste. In some parts of the city, more than 50 carters service a single neighborhood. Local Law 199 of 2019 began an overhaul of the system; the City will be divided into 20 zones with three carters per zone starting in 2024.

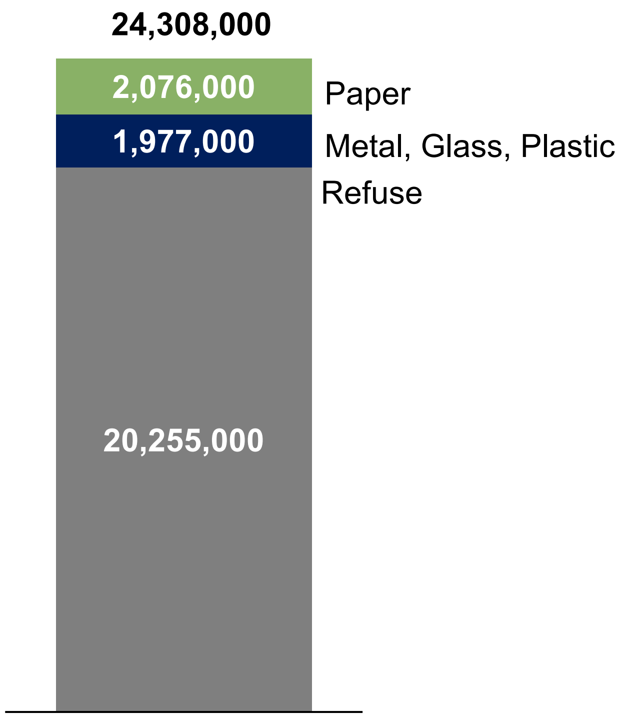


DSNY Commercial Waste Zone implementation plan, November 2018

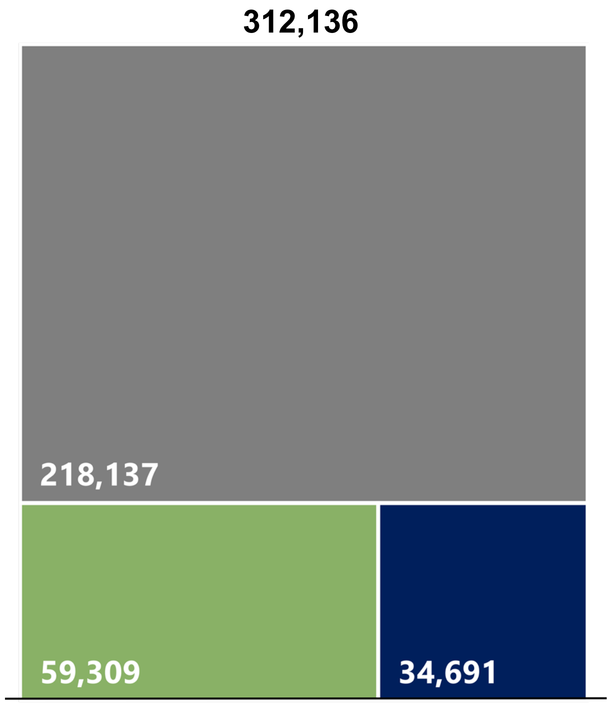
Residential Waste by Stream

DSNY collects waste in three separate streams citywide: refuse, metal/glass/plastic, and paper/cardboard. Additionally, curbside food and yard waste collection (organics) is available in Queens and will be rolled out in phases to every borough by Fall 2024. Accordingly, containerization solutions must provide the infrastructure and capacity for residents to separate all four of these streams at the curb in separate containers.

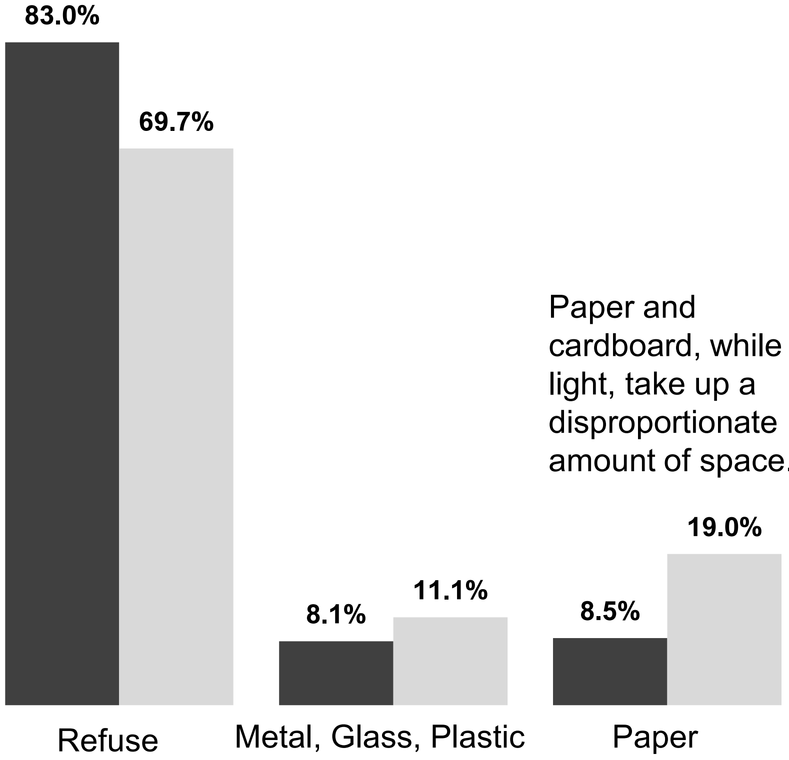
Average daily waste weight by stream[1]
pounds, thousands



Average daily waste volume by stream[2]
cubic yards



% Of daily weight vs % of daily volume



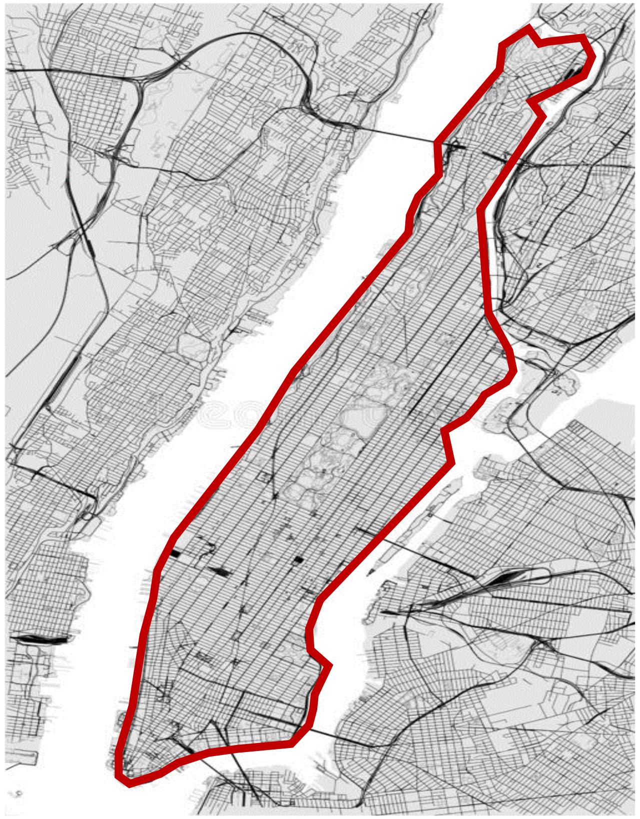
Paper and cardboard, while light, take up a disproportionate amount of space.

Residential Waste by Volume

Although generally measured by weight, waste must be assessed by volume for the purposes of containerization.

If the daily volume of waste was set out in a straight line one foot wide by one foot high, it would extend 37 miles: five miles longer than the entire perimeter of Manhattan.

1 cubic foot



Collection Operations

Waste Setout Rules

For decades, setout rules have allowed New Yorkers to set out all waste streams in bags on the curb at 4 pm the night before collection, with the relatively recent exception of food waste that must be set out in a bin.

On April 1, 2023, that changed, and New Yorkers are no longer allowed to place bags directly on the curb before 8 pm – a standard in line with other major cities.

Residents may set out their waste at 6 pm in individual bins (55 gallons or fewer with sealed lids), and businesses that close before 8 pm may set out their waste in individual bins an hour before closing.

These new rules heavily incentivize the use of individual bins for residents and businesses.

Current Types of Collections

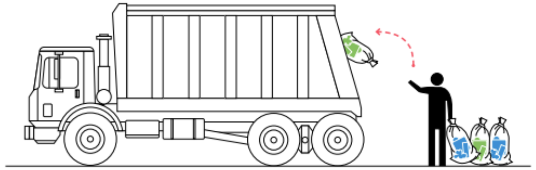
While the vast majority of DSNY's operations come in the form of bagged collection, approximately 11% of waste is already handled through containerized collection, in the form of roll-on/roll-off ("RO/RO") containers or front-loading "EZ Pack" containers, stored off-street. These containers are most common in public schools, New York City Housing Authority (NYCHA) developments, and large residential buildings.

Unfortunately, these containerization models are not scalable citywide because most residential buildings and many institutions generally lack the significant on-property space required to store RO/ROs and EZ Packs prior to collection or loading docks required for collection access.

Most EZ Packs that DSNY collects do not have wheels. RO/ROs have wheels but they are only used in loading the container on/off the truck (not for moving the container).

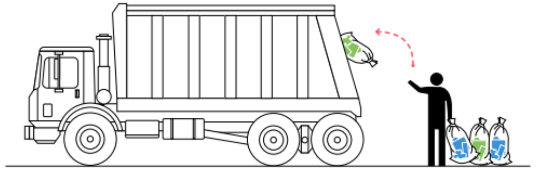
Non-containerized – 89%

Bagged collection, single stream



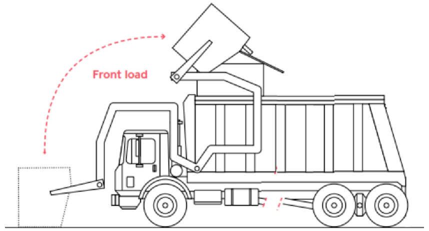
Illustrations: Center for Zero Waste Design.

Bagged collection, dual stream

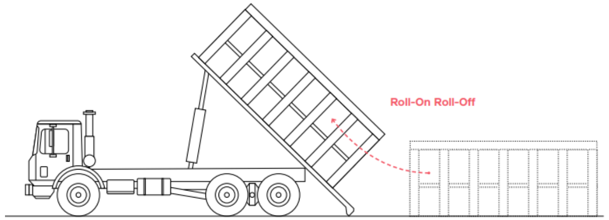


Containerized – 11%

Front loaded (EZ Packs)



Roll-on roll-off (RO/ROs)



School Waste

DSNY services over 1,400 New York City public school buildings in every neighborhood citywide. Given that the Department of Education (DOE) provides 800,000 meals for students every day, many of these sites produce a high volume of putrescible waste. Some of these larger set outs, while fully compliant with all City rules, are still highly visible.

DSNY, in partnership with DOE, runs 34 dedicated school truck routes citywide, servicing schools five days a week with trash, recycling, and organic material collection. Many schools – around 30% – are already containerized using EZ Packs for some part of their waste, but the remaining 70% leave their waste in bags on the sidewalk.

Schools present an opportunity for the City of New York to lead by example and demonstrate quick progress on containerization; a permanent containerization system at schools would make a significant difference for cleanliness and allow DSNY to continue to hone and refine implementation methods.

This is discussed in detail in the "Next Steps" section of this report.

Learnings from Citywide Containerization Pilot – “Clean Curbs”

DSNY is currently operating pilots of containerized waste collection across all five boroughs in commercial and residential locations. As part of the “Clean Curbs” pilot, DSNY installed steel enclosures on City streets in the parking lane, allowing Business Improvement Districts and residents (depending on pilot location) to set out their waste in stationary shared containers. These enclosures are collected daily by DSNY. The result has been an overall net improvement for the containerized areas, but not without challenges.

Accomplishments

- Clean Curb containers installed in 40+ locations to-date across all five boroughs, including 31 Business Improvement District (BID) locations and one residential block.

Key Learnings

- **This is not a scalable approach**, as bins require manual collection – with DSNY workers unlocking bins and loading bags into standard rear-loader trucks by hand – sometimes taking several minutes per stop. Additionally, bins are not sufficiently large to accommodate the volume of waste on most mid-to-high density streets.
- **Siting shared containers** so they can be accessed from the sidewalk and street without being blocked by vehicles required removing parking spaces. Even if a location met siting requirements, many partners otherwise interested in containerization did not want to remove parking.
- **Maintenance costs** can be significant and include shoveling snow to maintain access, power washing shared containers, removing graffiti, and cleaning overflow and litter.
- **Significant behavioral change** is required to operationalize residential shared containers. Even with extensive community outreach to residents and supers, an unacceptable amount of trash continues to pile up around the shared containers, even when they are not full. This solution cannot work without massive community buy-in.

Challenges for Shared Containers

Complicating Factor – *Population Density*

Population density is a critical complicating factor for implementation of shared containers in areas where they would be most appropriate. The large volumes of waste produced in small geographies can require prohibitively large containers at current collection frequency – based on sheer curbside space alone, to say nothing of design and aesthetic considerations.

New York City is the largest city in the United States, with more than twice the population of the second largest city, Los Angeles. Individually, New York City's boroughs would rank among the largest cities in the country.

Population per square mile in major global cities[1,2,3,4]

City	Population per sq. mile	Population
New York City	***29,303***	***8,467,513***
Manhattan	***71,900***	***1,628,700***
Paris	53,210	2,165,423
Barcelona	42,255	1,666,530
London *Inner London*	14,837 *29,467*	9,006,352 *3,624,536*
Chicago	12,060	2,696,555
Los Angeles	8,304	3,849,297

Cities that currently leverage shared containers tend to have substantially lower population densities, and produce significantly less waste per square mile than New York City. In many of these cities' urban cores, building height limits are capped at 6 stories.

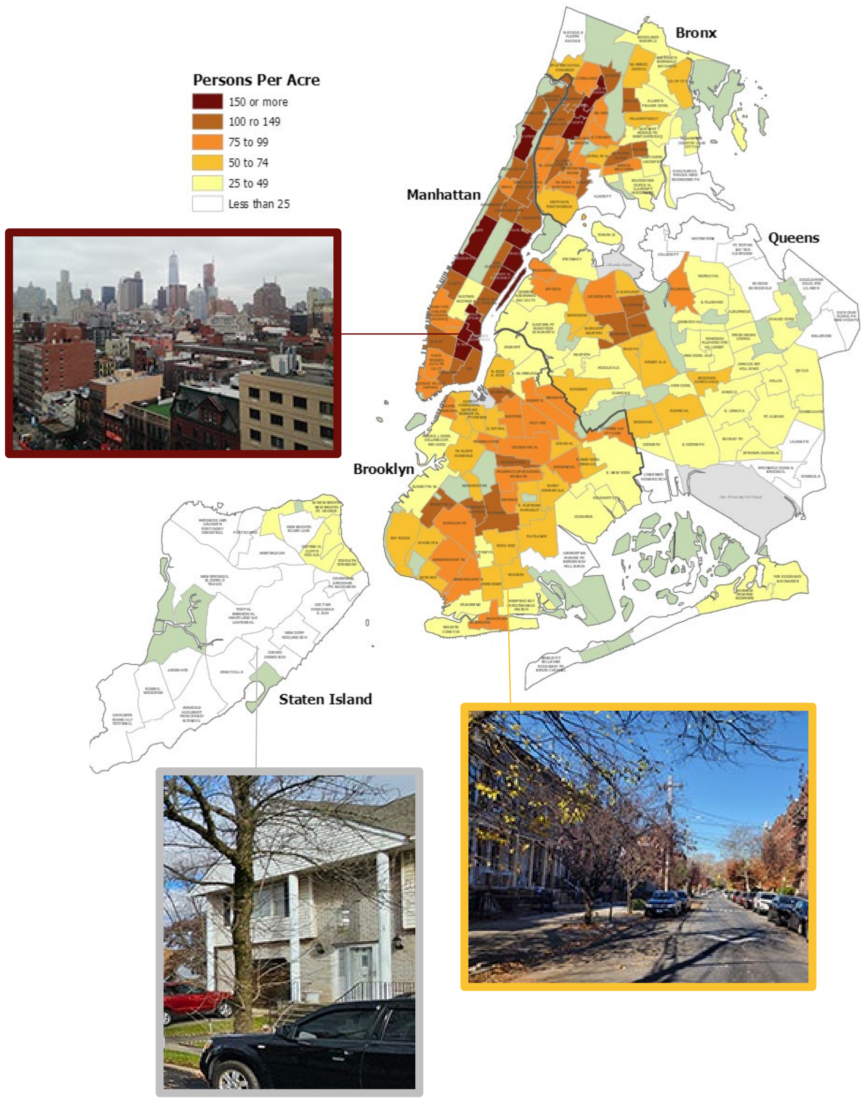
Within New York City, there is a substantial range in population density. Peak density – and the highest concentration of accumulated refuse – falls in Manhattan, which houses roughly 20% of the total population in less than 8% of the land area: 1.7 million New Yorkers and over 900,000 housing units in just 23 square miles.

This is in stark contrast to other parts of the City, like Eastern Queens or Staten Island; the latter has fewer than 500,000 residents across 59 square miles (20% of the City's land area).

Containerization takeaways:

- The solution for New York City is not "one size fits all" and would require different containerization solutions based on density.
- Containerizing New York City's high-density neighborhoods presents a unique challenge.

Population density, New York City (2010)[5]



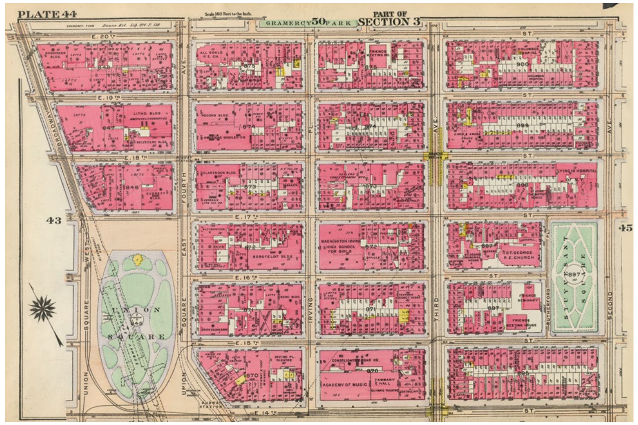
Complicating Factor – *Built Environment*

In New York City, the lack of alleys has had a significant impact on trash collection. Many other cities in the United States store individual bins for households and businesses tucked away behind buildings. The vast majority of New York City streets do not have such alleys or rear access points. The lack of alleys means that most buildings have their main entrances facing the street, and large shared containers have to be placed on the curb.

New York City's street grid system, which was first proposed in the 1811 Grid Plan, was intended to maximize the use of limited space and create a straightforward layout for the City's streets. The plan established a grid of numbered streets and avenues, with each block measuring 200 feet by 600 feet. The streets and avenues were to be straight, crossing at right angles, and did not provide for any alleys between blocks.[1]

Trash must go somewhere. The lack of alleys – combined with the density and volume of trash produced in New York City – leads to the accumulation of large curbside piles ahead of collection.

1811 Grid Plan[2]



Union Square Area, 1916[3]

Some cities around the world free up curbside space by storing waste below ground. This is not a viable approach in most parts of New York City and, in particular, Manhattan, because of the vast web of existing underground infrastructure that exists.

New York City's underground is home to a network of over 160,000 miles of utility infrastructure that includes water and sewer pipes, gas lines, electrical conduits, steam pipes, and telecommunications cables, some of which are owned and operated by the City of New York, and others by private utility companies pursuant to franchise agreements with the City.[4] A precise mapping of the location and depth of the infrastructure does not currently exist, making any large-scale below-ground trash containment program unrealistic.

Containerization takeaways:
- The absence of alleys and underground space means that New York City's residential waste has to be stored for collection curbside (with the exception of some large buildings with loading docks).

The Network of pipes under Manhattan's streets

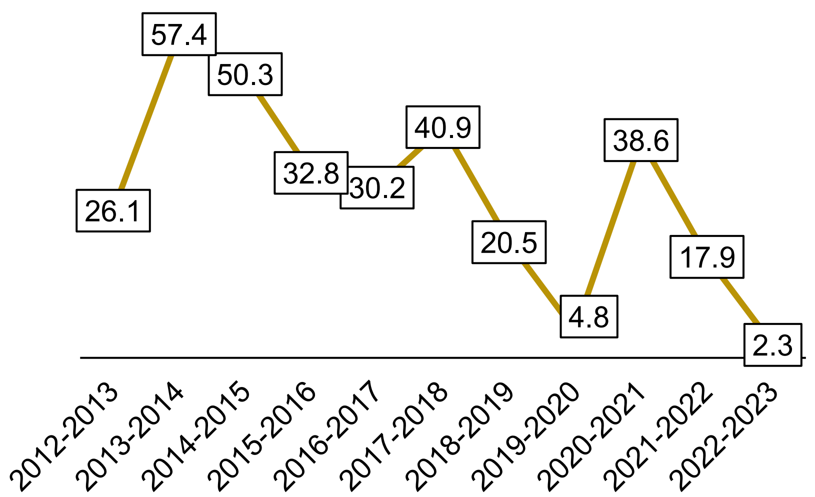
Complicating Factor – *Weather*

Snow adds operational complexity to trash collection. Plows push snow into the curb line in order to clear streets, creating large banks that block access to trash on the curbs.

Shared containers are either wheeled, which requires the bin to have an unobstructed path to a truck, or stationary, which requires mechanized collection trucks to be able to consistently access the curb. While stationary shared containers can potentially be cleared of snow for collection, wheeled shared containers are likely to get stuck or frozen.

An advantage of the bagged collection of trash and recycling is that it allows sanitation workers maximum flexibility to navigate these conditions.

The average annual snowfall in New York City over the past 10 years was 30 inches; snowfall was as high as 57.4 inches in the 2013-2014 season, with nearly 30 inches in the month of February alone.[1]



Most global cities that have mechanized trash collection through large, above-ground containerization systems required of New York City's high-density areas do not have substantial snowfall. Cities that do have to contend with snow fall, such as Amsterdam or Zurich, employ an underground container system that limits the impact of weather.

Snow is navigable for individual bins. For example, Toronto encourages residents to place individual bins next to snowbanks instead of behind them, and asks that residents shovel out space and ensure a clear path from the bins to the road.

Containerization takeaways:

- Large wheeled containers present a challenge in snow and are not viable at scale.
- Any containerization solution must consider a snow maintenance plan to clear snow from shared containers ahead of collection.

Complicating Factor – *Curb Space*

When trash is placed on New York City's streets every day, it is being set out on one of the most sought-after pieces of real estate in the world. Shared containerization combines the existing footprint of trash bags into common receptacles in the curb lane to keep leaking trash bags off of the sidewalks, away from rats, and out of the pedestrian right of way, as well as to allow for reliable access to collection vehicles.

New York City has 76 million feet of curb space citywide, used by public parking, bike lanes, bus lanes, loading zones, outdoor dining, and throughways.[1] Shifting the siting of trash setouts from sidewalks to permanent use of curb lanes creates competition with current uses of the space.

Currently, curb space is predominantly occupied by approximately 3 million on-street parking spaces.[2] In total, the City allocates 80% of all available curb space to on-street parking, and a combined area equivalent to 12 Central Parks.[3] Around half of these spaces, or 1.5 million total, are on residential streets that would be affected by containerization.[4]

DSNY's analysis found that, of the approximately 1.5 million parking spaces on residential streets, a citywide shared container program would account for a 10% reduction in parking on residential streets citywide, and up to 18% in a single community district. Not all neighborhoods would see a repurposing of parking spaces, as the use of shared on-street containers is not appropriate for single-family and low-density street sections; a geography of curb use concentration is provided in the "Analysis of Containerization Models" section.

The New York City Department of Transportation's forthcoming report on curb management assesses current uses of the curb and will contextualize containerization in a broader strategy of rebalancing the City's use of public space.

Containerization takeaways:
- Any shared container solution would result in tradeoffs with current use of curb space.

Complicating Factor – *Collection Frequency*

DSNY provides door-to-door waste collection service for all residential households, public schools, public buildings, and select private institutions in New York City. The operation is run by 8,200 sanitation workers stationed at 59 garages citywide, who operate 2,000 collection trucks running 7,200 weekly collection routes.

The trucks and staffing levels are set based on the historical precedent of a set level of service days for residents. Frequency of collection is based on a variety of factors, including the volume of waste generated, environmental impact of collection, and cost. Currently, collection frequency for refuse is either two or three times per week, while recycling (both metal/glass/plastic and paper streams) is once per week. Organics collection frequency is planned to mirror recycling frequency at once per week when it is rolled out to each borough through the end of 2024.

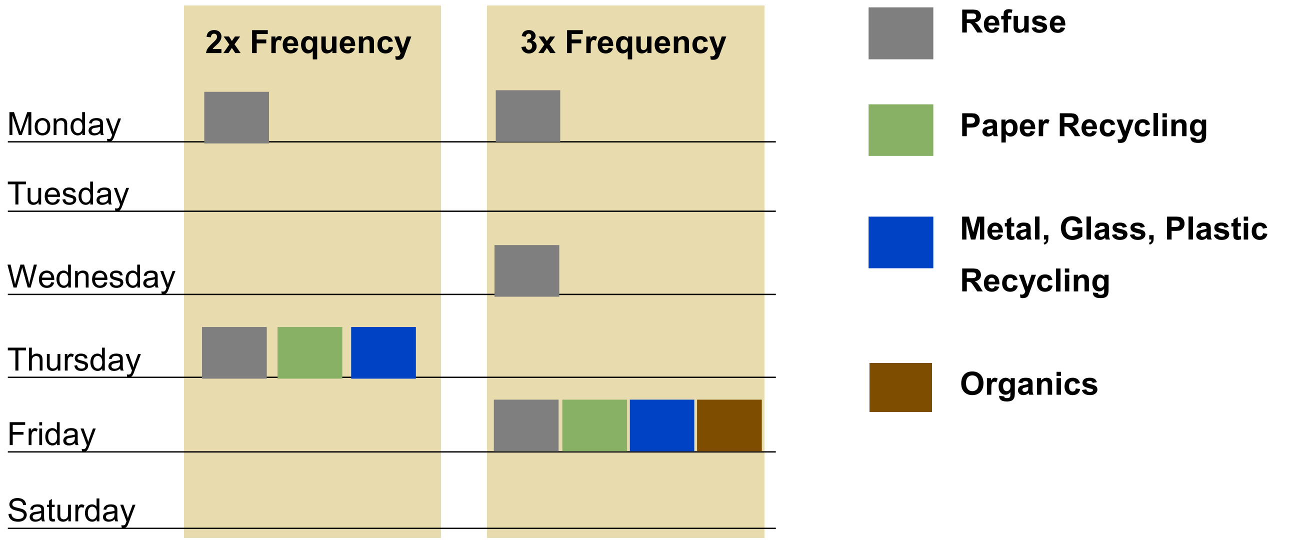
Cities that have rolled out shared containers generally collect trash daily, as often as twice per day.

In New York City, current frequency levels would require an unreasonable number of shared containers on high-density residential streets. Changing collection frequency would require a short-term inflation of staffing and fleet to accommodate the additional service level until residential behavior changes to flatten the setout volume across days of collection.

Refuse Collection Frequency, New York City

City	2x Frequency	3x Frequency
New York City	***71%***	***29%***
Manhattan	0%	100%
Bronx	52%	48%
Brooklyn North	28%	72%
Brooklyn South	97%	3%
Queens East	100%	0%
Queens West	96%	4%
Staten Island	100%	0%

Example Collection Schedules



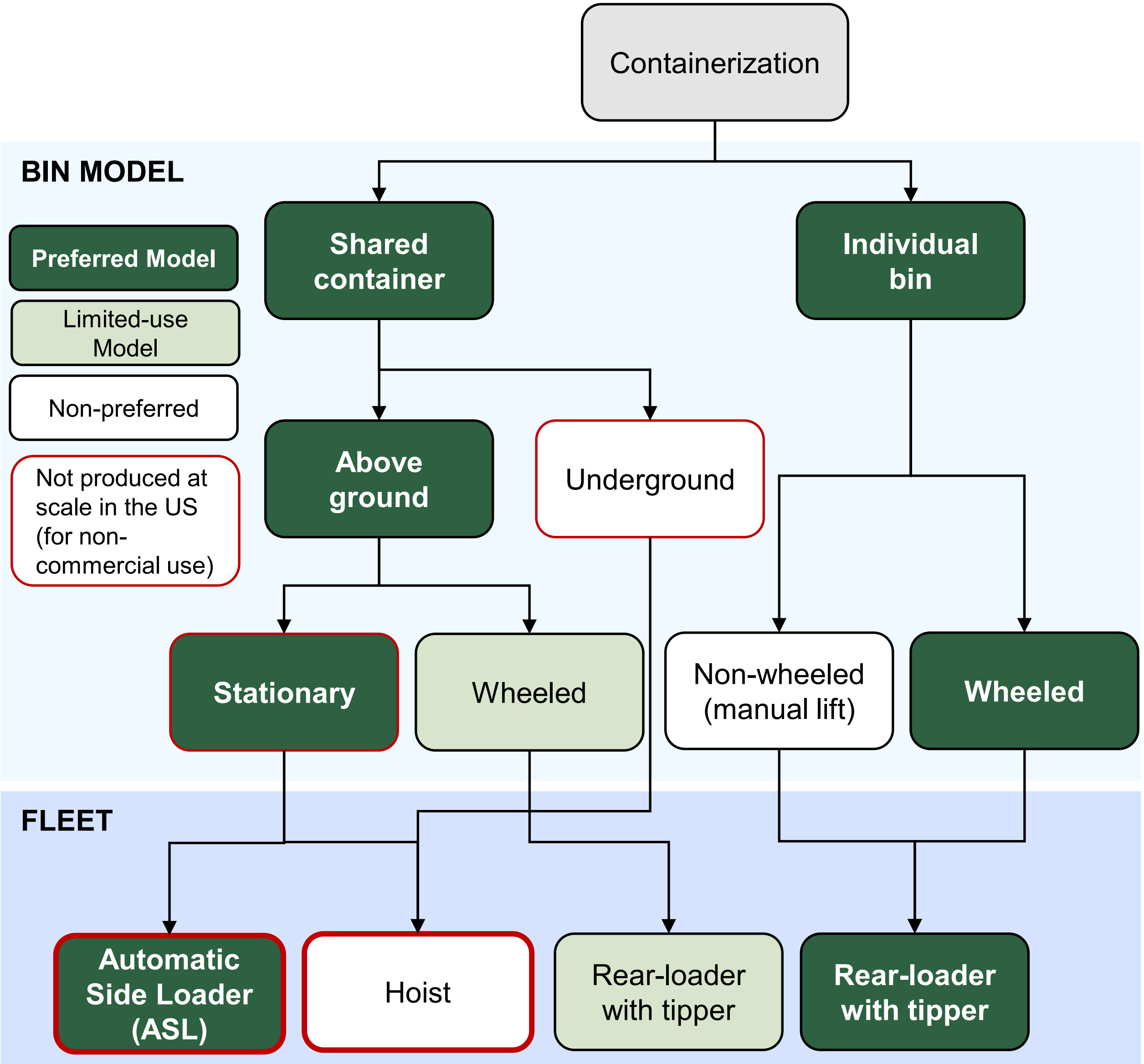
Complicating Factor – *Container Model and Fleet*

Containerization requires a fleet that is compatible with the selected shared containers. Compatibility hinges on whether bins are stationary or wheeled and, if stationary, how containers are loaded into trucks. There are two primary considerations: would DSNY need a new collection truck and, if so, which truck model is optimal?

To wheel or not to wheel is the pivotal decision point that determines whether a new truck is required. Stationary shared containers are the only path to high-density residential containerization **at scale**: they are safe, reliable, and occupy less space than individual bins. However, the only shared container design option that is compatible with DSNY's existing rear-loader fleet (with retrofits) is wheeled shared containers. Wheeled shared containers are faster to implement than stationary shared containers but are not the right solution at scale for several reasons: they have a smaller capacity (because they need to be manually movable); their wheels break often; they require an additional enclosure to secure on the street; they can be stolen or moved without authorization; and their wheels are not reliable in snow and ice. There are, however, certain situations in which wheeled containers are viable for use in early containerization pilots and to service institutions.

Stationary shared containers can be serviced by an automatic side loading (ASL) or a hoist truck, each with costs and benefits; DSNY's strongly preferred model is the ASL over the hoist truck. NYCHA is planning to pilot a hoist truck at off-street locations; however, this model presents safety risks when used on-street, with shared containers suspended above cars and pedestrians, and many City streets cannot accommodate the requisite 20-foot overhead clearance.[1]

Neither the ASL nor the hoist truck are currently available at scale in the U.S., and the ones manufactured in small numbers are not built to service a dense urban environment. The process to design, test, and manufacture the fleet needed for scaled shared stationary containers in New York City would take a minimum of three years and significant capital investments to complete. The tradeoffs and requirements are detailed further in the "Analysis of Containerization Models" section.



Complicating Factor – *Two Different Paradigms*

In New York City, commercial trash is collected by a network of private carters and not by DSNY. This dichotomy presents a challenge to universal citywide containerization and the goal of getting trash bags off the streets.

New York City contains a large number of mixed-use neighborhoods, where residential and commercial trash appear on the same curb line. If residential trash is containerized and commercial trash is not, a mixed-use street section with both residential and commercial properties would continue to have bags on the street despite the significant behavioral change required of residents.

Shared containerization of commercial waste is a complicated problem to solve for, given the way the private carting system is set up. A network of over 90 private carters charge customers based on tonnage, and businesses are likely to use a different carter than their neighbors. This reality prohibits the use of containers shared between businesses.

The same challenge will persist even when the new Commercial Waste Zone law is implemented, limiting the number of private carters to three per zone, with 20 zones across the City.

There are, however, significant improvements to be made in the area of commercial waste management. Individual bins are viable for small street-facing businesses. The new setout time rules implemented by DSNY on April 1, 2023 already encourage individual bin use by businesses, however further action may be warranted given that many businesses produce a disproportionate amount of food waste, which is attractive to rodents.

Additionally, the City can incentivize developers of large office complexes to include on-site loading docks, which allow for in-building containerization and specialized collection.

International Best Practices

Key Findings from International Analysis

1. Shared containers **require significant increases to collection frequency:**
   - In Europe, collection frequency is typically six to 14 times per week (yes, up to twice a day!)
   - In New York City, collection frequency is only two to three times per week depending on density.
2. Europe has tested multiple different containerization models over decades, and **almost all cities are doubling down on the strategy of shared containers** collected using specialized side-loaded or hoist trucks:
   - Underground containers are the preferred model for some cities, but this requires substantial space to build underground and a comprehensive underground map that does not exist in New York City.
3. **European containerization faces many challenges** – for example, shared containers are often overflowing and surrounded by loose bags of garbage:
   - This leads to wildly inefficient collection operations – because the standard collection trucks have mechanical lifts for shared containers, cities must run second dedicated trucks to collect the loose bags along the route.
   - This is solvable with a truck that can side-load shared containers and accept loose bags.
4. While containerization is standard practice in Europe, **no major city in North America uses shared stationary containers at scale:**
   - Practically, this means that North America does not currently have access to fleet and bin manufacturing that is widely available in Europe.

Major Global Cities Are Already Containerized – With Mixed Results

● Deep dive conducted on city

Amsterdam

Mostly underground; some individual bins & pneumatic

Milan

Primarily individual bins; shared containers for recycling centers.

Paris

Mostly individual bins for refuse, shared for recycling

Shenzhen

Mostly individual bins; some shared containers

Barcelona

Mostly shared; some individual bins, pneumatic, bags

Buenos Aires

Mostly stationary shared containers

Singapore

Mostly chutes; some pneumatic & individual bins

Comparison of Global Models of Containerization

City	Individual bin	Stationary shared container	Wheeled shared container	Mobile container	Under-ground container	Pneumatic system	Notable aspects of containerization
Amsterdam	✓	✓	✓		✓	✓	Innovation (e.g., electric boats)
Bangkok	✓	✓					
Barcelona	✓	✓		✓	✓	✓	High resident satisfaction
Beijing	✓	✓					Innovation (e.g., QR code bins)
Bergen	✓	✓	✓			✓	Widespread pneumatic by 2023
Berlin	✓	✓	✓				
Boston	✓						Seasonality / snow
Buenos Aires		✓					
Busan	✓	✓					
Chicago	✓	✓	✓				Seasonality; rat-proofing
Curitiba		✓					
Hong Kong	✓	✓	✓				
London	✓		✓		✓	✓	Diverse streetscape; many models
Madrid	✓	✓	✓	✓	✓		Piloted sensors; mobile containers
Melbourne	✓		✓				
Milan	✓	✓					
Munich	✓	✓	✓				

For each of these cities, where applicable, DSNY examined:

- Approach to selecting containerization model (e.g., based on residence mix and/or streetscape)
- Approach to placement of shared containers
- Approach to issues relevant to New York City including:
  - Selecting model based on residence mix and/or streetscape
  - Placement of shared containers
  - Adjustments or mitigations given seasonality
  - Routing (including dynamic routing)
  - Fleet implications to each model
  - Strategy around resident behavior
  - Complexity of underground & aboveground infrastructure

Comparison of Global Models of Containerization, *cont.*

City	Individual bin	Stationary shared container	Wheeled shared container	Mobile container	Under-ground container	Pneumatic system	Notable aspects of containerization
Osaka		✓					
Paris	✓	✓	✓				Individual bin system, high frequency
San Francisco	✓		✓				
Seoul	✓	✓	✓		✓	✓	
Shanghai	✓	✓					
Shenzhen	✓	✓					
Singapore	✓	✓	✓			✓	Pneumatic system
Stockholm	✓	✓				✓	
Sydney	✓	✓	✓		✓		
Taipei							
The Hague	✓	✓			✓		Underground containers
Tokyo		✓					
Toronto	✓	✓					
Washington DC	✓						
Yokohama							
Zurich		✓	✓		✓		Underground & above ground

For each of these cities, where applicable, DSNY examined:

- Approach to selecting containerization model (e.g., based on residence mix and/or streetscape)
- Approach to placement of shared containers
- Approach to issues relevant to New York City including:
  - Selecting model based on residence mix and/or streetscape
  - Placement of shared containers
  - Adjustments or mitigations given seasonality
  - Routing (including dynamic routing)
  - Fleet implications to each model
  - Strategy around resident behavior
  - Complexity of underground & aboveground infrastructure

Comparison of Global Models of Containerization, *cont.*

Title	Approach to model selection	Approach to placement	Seasonality	Routing	Fleet implications	Encouraging resident behavior	Streams	Under and overground infrastructure
Amsterdam	Prioritize underground	<120 meters for refuse Pinned on map to encourage use	Underground containers limits impact of cold/heat	Piloted and subsequently canceled dynamic routing	Varied fleet, for underground (but cannot pick up loose bags) vs. aboveground	"Beautifying" container area to discourage loose bags; social pressure	4 streams – refuse, textiles, glass, paper	Underground wherever possible; piloting pneumatic
Barcelona	Based on residence mix and streetscape	<100 meters Separate containers for all streams	N/A – mild temperatures year-round	-	Varied fleet, which cannot pick up loose bags	-	5 streams (includes organic, MP separated from G)	Expanding pneumatic in new developments only
Paris	Based on resident mix	Refuse in all buildings; recycling in building / street	N/A – cold, but no snow	Not optimized; prioritize cleanliness	Same trucks for bins & shared containers	-	Daily collection of waste across multiple streams	Primarily using aboveground
Shenzen	Prioritized shared container, size based on resident mix (i.e., more units, higher volume)	Designated areas for refuse <50 meters of residences	N/A – mild temperatures year-round	Optimized with data, but not dynamic for residential	Mostly homogeneous fleet (~90%) given only 2 sizes of bins	Government oversight	3 streams – recyclables, kitchen waste, harmful waste, and other	Piloting pneumatic, unlikely to scale given infrastructure challenges
Singapore	Based on residence mix (majority high-rise)	In building / driveway	N/A – mild temperatures year-round	Optimized, consistent resident behavior	Mostly homogeneous fleet given common containers	Education campaigns on proper sorting	Paper and MGP collected together	Expanding pneumatic in new developments only
Zurich	Sequence of priority: large underground, large above ground, small bins	-	No recorded issues with mechanized pickup	-	Varied fleet, for underground vs. aboveground Compartments for recycling streams	Reinforcement mechanisms for recycling rules; per-person waste tax	8 streams with distinct containers	Underground wherever possible 2/3 above- and 1/3 underground

Best Practices and Lessons Learned

	Practices to be considered for New York City	Practices that could present challenges
Design	✓ Simple consistent design for both individual bins and shared containers can enable a homogenous fleet, designed to accommodate multiple types of pick up, including overflow (e.g., Paris's rear-loading trucks accept bins, wheeled shared containers, and loose bags).	✗ Smaller openings to shared containers can support proper recycling, but increase risk of residents placing loose bags next to shared containers when waste won't fit easily (e.g., per experts, Barcelona continues to struggle with loose bags; also more prone to breakage).
Technology	✓ Mechanized lifts can mitigate collection inefficiencies caused by ice and snow. ✓ Mechanization cited as less labor intensive versus manual where those manually loading waste into a rear-load truck are estimated to lift an average of 13,000 pounds a day. ✓ Managing access (e.g., through key fob) to shared containers can help mitigate low recycling rates and illegal dumping, though it increases risk of loose bags next to containers and illegal dumping in "No Man's Land" areas.	✗ Sensor systems tested in some cities can be expensive, require significant maintenance, and may not fully enable implementation of dynamic routing (e.g., Amsterdam piloted sensors but found the required maintenance and behavior change inhibited more efficient collection). ✗ Pneumatic systems have typically been implemented only in greenfield development (e.g., New York City's Roosevelt Island; London implemented in few neighborhoods, including Wembley, as a part of broader redevelopment) and often clog due to improper use.

Best Practices and Lessons Learned, *cont.*

	Overview of learnings	
Complexity of underground & aboveground infrastructure (1/2)	**Cities tend to only implement pneumatic containerization solutions in areas that are being redeveloped, with limited instances of retrofitting**	**Barcelona**: City installed pneumatic system in an area redeveloped for the 1992 Olympics, but the system had an estimated 25-year return on investment and the city has not expanded beyond this area because officials believe that it is "nearly impossible" to install a pneumatic system on top of existing infrastructure, per expert interviews. **Singapore**: Mandates that new non-landed private developments with 500+ units must implement a pneumatic system, however despite the vast majority of the city living in high-rise buildings, the city is only requiring pneumatics in new construction given the complexity and cost involved (approximately five percent of buildings have a pneumatic system currently). **London**: A pneumatic system is being built as part of the transition of the neighborhood surrounding Wembley Stadium from parking lots and industrial units to mid-rise residential and commercial buildings. • In 2011, it was estimated to cost £16M and the construction continues to be underway today (expected to be completed in ~2025). **Bergen**: In 2010, the city was already planning on installing district heating in the city center, renovating the sewage system, and building a new tram line, which allowed for the city to include a pneumatic system in the construction.
	Cities that have implemented underground solutions outside of redevelopment had existing comprehensive data on underground mapping	**Amsterdam**: City is able to implement underground containers given the metro system only has five lines, some of which are aboveground and the city has a central database that includes a mapping of the underground cables and infrastructure, which is used as an initial guideline for underground container placement. **The Hague**: City has published guidelines on how it evaluates placement of a container, which includes cables and pipes; underground transportation is not a consideration given the only metro line is from the Hague to another city (i.e., limited underground transportation within the city). • Full process from start to finish only takes ~6 months to install underground container, including evaluating the underground infrastructure, impact on parking, accessibility for trucks (e.g., trees, lampposts), digging, placing the containers, and refinishing the street/sidewalk on top.

Best Practices and Lessons Learned, *cont.*

	Overview of learnings	
Complexity of underground & aboveground infrastructure (2/2)	**Dense aboveground infrastructure leads cities to use either smaller trucks or rear-load trucks (given side loaders or front loaders require more space during collection)**	**Chicago**: Narrow alleys present limited ability to use any trucks other than rear-load trucks. • Given these limitations, per expert interviews either the containers must have wheels so they can be placed behind the truck for collection, or the alley must be large enough for the truck to turn around and back up to the container. **Barcelona**: Leverages smaller electric trucks to reach neighborhoods with narrow/pedestrian streets (*i.e.*, trucks have width of 1.9 meters and can collect only four to five tons). • However, per expert interviews, these vehicles can present challenges with gradient and battery life, so there are limited instances where these trucks can be implemented – particularly in New York City, where trucks must be capable of conducting rapid removal of snow and ice. **Amsterdam**: In areas with particularly narrow streets, the city has begun collecting waste with electric bicycles; residents are able to select a time for the waste to be collected through an app, which includes capabilities for collection of five different streams.

Analysis of Containerization Models

Key Findings

1. **Containerization is not a one-size-fits-all solution and must accommodate the diversity in residential density and associated waste output**, from single-family low-rise communities in Staten Island and Eastern Queens to high-rise apartment buildings with hundreds of units producing thousands of pounds of waste per day in the densest parts of Manhattan.

2. **Containerization in the form of individual bins and shared containers fixed to the street is possible for the vast majority of the City;** 89% of New York City streets with residential properties and 77% of the City's total residential waste output can be containerized without occupying more than 25% of available street space.*

3. **Shared containers, in particular, require:**

   a) **The use of stationary shared containers instead of wheeled shared containers.** Wheels are not a reliable, scalable solution for New York City; a reality reflected in the fact that other cities are not relying on this model for their containerization systems.

   b) **Substantial R&D investment** to create fleet and stationary shared container production capacities that do not exist today in North America, but are widely available in Europe, and to a lesser extent Asia and South America. Practically speaking, because no major city in North America uses residential stationary shared containers at scale, the industry would have to develop a first-of-its-kind truck for the region.

   c) **Significant increases to collection frequency** in high-density areas in order to accommodate the volume of waste in a reasonable footprint on the street.

   d) **Rebalancing use of curb space,** including repurposing approximately 10% of on-street parking spaces on residential streets while maintaining space for other curbside programming like bike lanes, bus lanes, and dining.

* Methodology and data sources used in this analysis can be found in the appendix to this report.

Containerization Model Evaluation

Containerization Model Evaluation

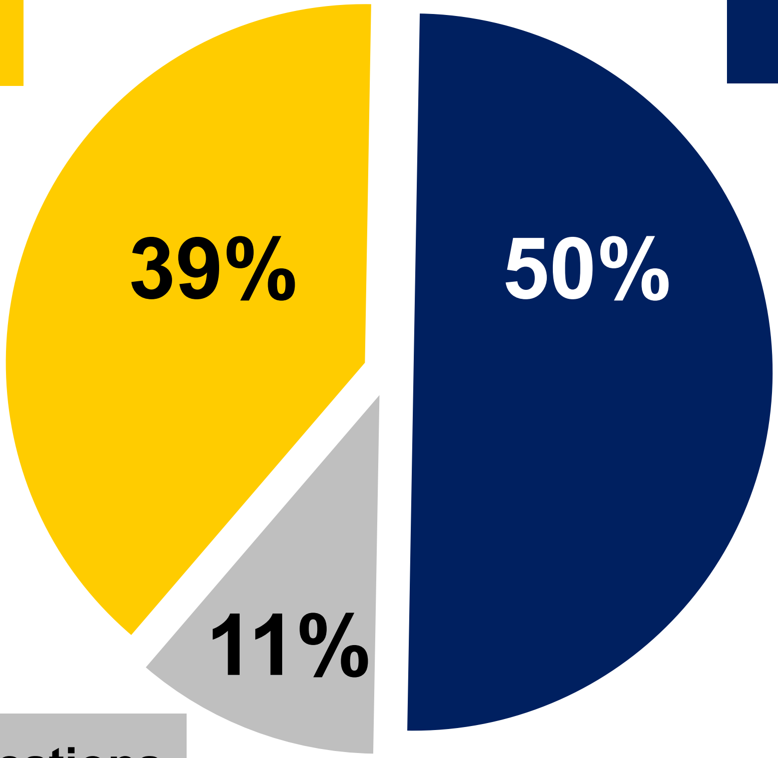
Containerization is *not* a one-size-fits-all solution to New York City's current trash problem.

On 50% of residential streets, waste-per-residence can be sufficiently containerized in individual bins that are already commonly used by many households (and had been required by the City until the late 1960s).

However, on 39% of residential streets, waste cannot be reasonably accommodated by individual bins and requires a shared container solution.

The remaining 11% of residential streets produce a disproportionate volume of waste relative to available on-street area, and are even more challenging to containerize, even with aggressive collection frequency increases.

Shared containers



Individual bins

<u>Very</u> hard locations

Not enough space for volume of trash produced

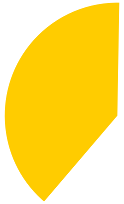
Containerization Model Evaluation, *cont.*

Any containerization model selected for implementation must fit the needs of the street section (a single block face), determined by residential density and current waste output.

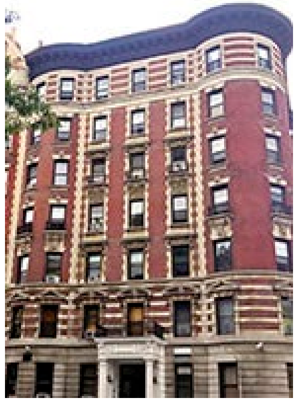
Shared containers are well suited for mid-to-high density neighborhoods where individual bins are impractical and inefficient, with stationary bins presenting the best long-term scalable solution for these neighborhoods.

Individual bins are best suited for low-density areas, where many residents already place bins on the curb for collection.

Shared containers



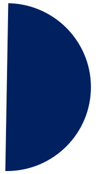
39% of residential streets



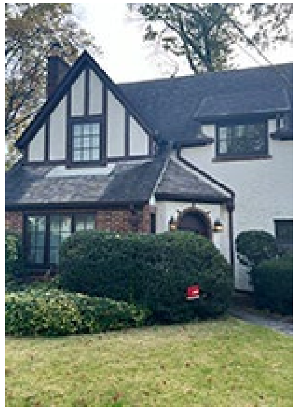
Mid density
Buildings <150 units

High density
Buildings >150 units

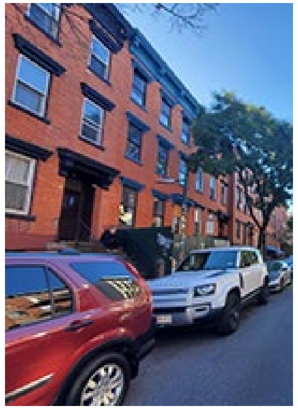
Individual bins



50% of residential streets



Single family
1-2 unit homes



Low density
3-6 story row houses

Containerization Model Evaluation, *cont.*

The case study below illustrates how the two different models (individual bins and shared containers) affect the same streetscape in meaningfully different ways. In one mid-size building containing 21 units over five floors, the waste tonnage at current collection frequency would require 40 individual bins. This would create impassable sidewalk conditions. Alternatively, the same building can fit its waste in four large shared containers, taking up two parking spaces, which would be shared with adjacent buildings.

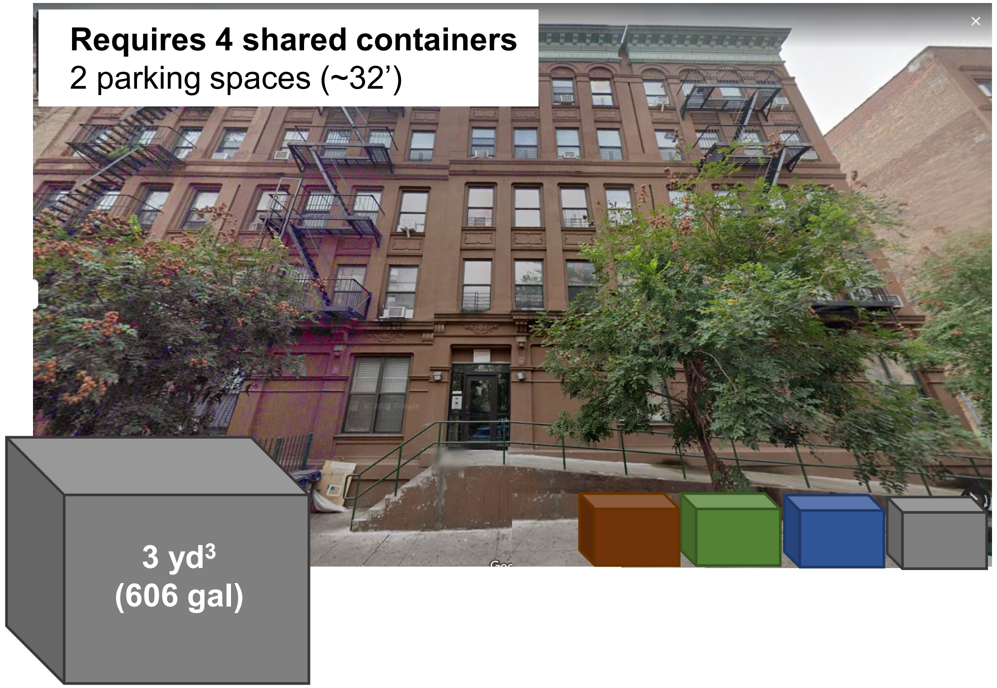
Single Building Case Study:

Density: 21 units on 5 floors

Frontage: 75’

An excessive number of individual bins is required for setout in this mid-density building, disrupting pedestrian experience of sidewalks.

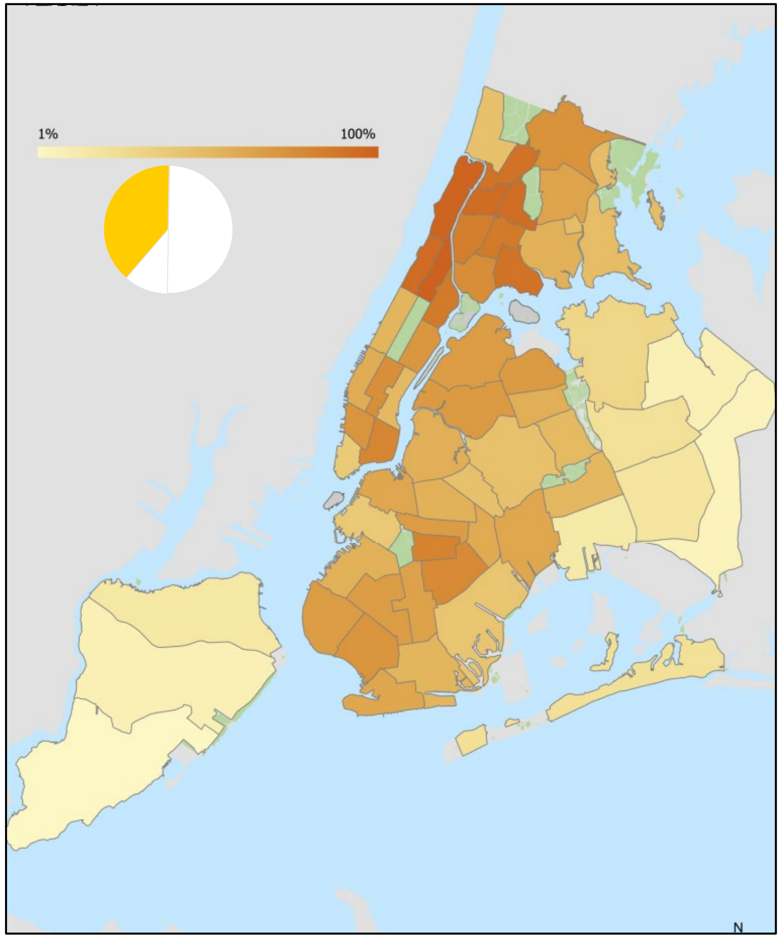
Four shared containers across two parking spaces are required for setout in the same mid-density building, with a much smaller footprint on the curb.



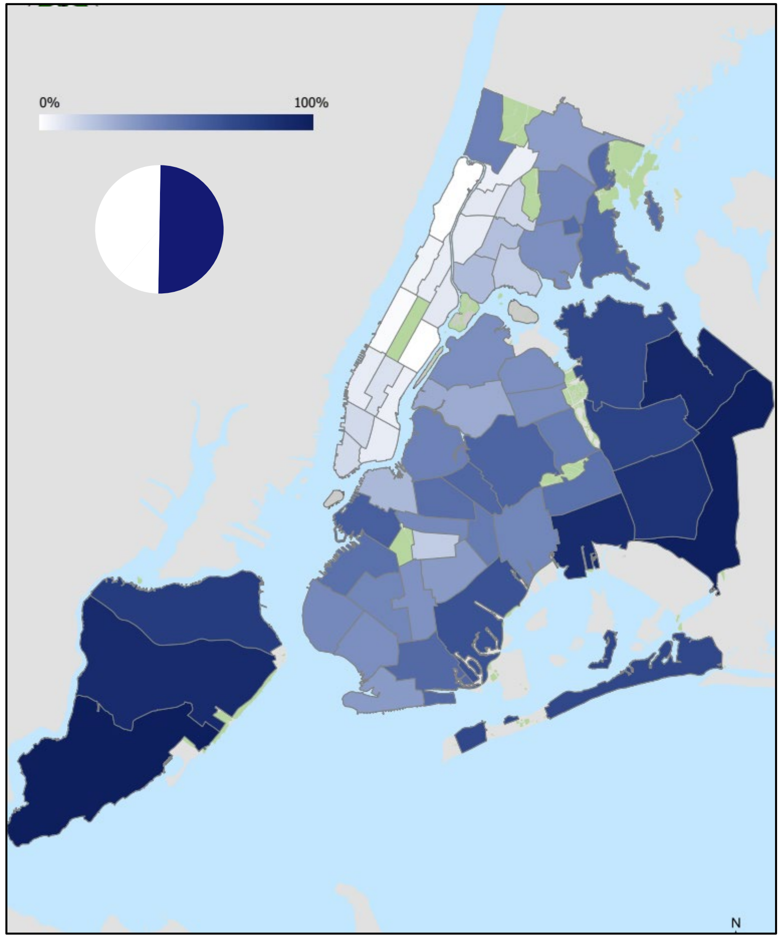
Containerization Model Evaluation, *cont.*

The optimal containerization model doesn't just vary neighborhood-to-neighborhood, but street section to street section. Generally, shared containers should be concentrated in Manhattan, large portions of the Bronx, Northwest Queens, and Central Brooklyn, with Staten Island, Eastern Queens, and parts of South Brooklyn using individual bins.

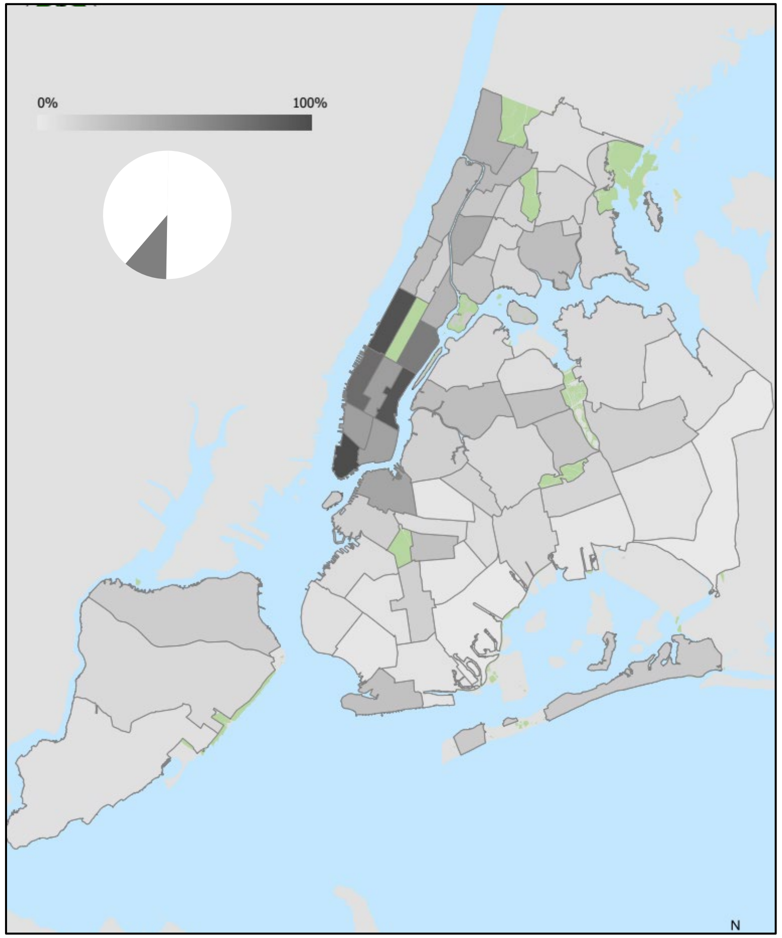
Shared Containers



Individual Bins



Very Hard Locations



Containerization Model Evaluation, *cont.*

New York City's residential street sections can be broken into eight different archetypes based on waste output.

Waste output generally tracks residential density. While the single-family homes and row houses archetypes account for over 50% of New York City street sections, they make up just 21% of total daily waste tonnage.

Archetypes with larger buildings (50-150 units, high-rises, hybrid high-rise mixes) account for only 10% of the city's streets, but disproportionately account for over 1/3 of the City's residential waste.

Full list of archetypes	Street sections Number	Street sections Percentage	Daily waste tonnage Tonnage	Daily waste tonnage Percentage
1 1-2 family homes	~25K	37	1.5K	10
2 Hybrid with mixed residence types (no 150+ unit)	~22K	32	5.4K	37
3 1-6 story row houses	~11K	16	1.7K	11
4 Multi-family building with 50-150 units	~4K	6	2.3K	16
5 Multi-family building with 10-50 units	~3K	5	1K	7
6 High-rise buildings (150+ units)	~2K	2	1.5K	10
7 Hybrid with 1+ high-rise (150+ units)	~1K	2	1.4K	9
8 Edge cases, incl. campus-like development (e.g., Stuyvesant Town) or "unevenly" distributed (e.g., commercial with few residential units)	<1K		<0.1K	1
Total	**~69K**		**~15K**	

Containerization Model Evaluation, *cont.*

Street sections with single-family homes and low-density row houses – 50% of residential streets – can be containerized with individual bins and serviced by retrofitting existing vehicles. Streets with higher-density residential properties must consolidate waste in shared containers installed at the curb, which would be serviced by an automated collection vehicle.

Residential archetypes

1

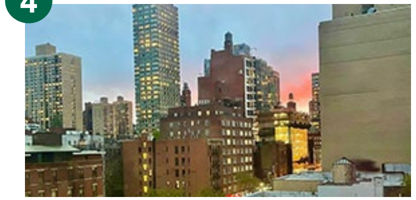

Single family
1-2 family homes

2


Low density
3-6 unit row houses

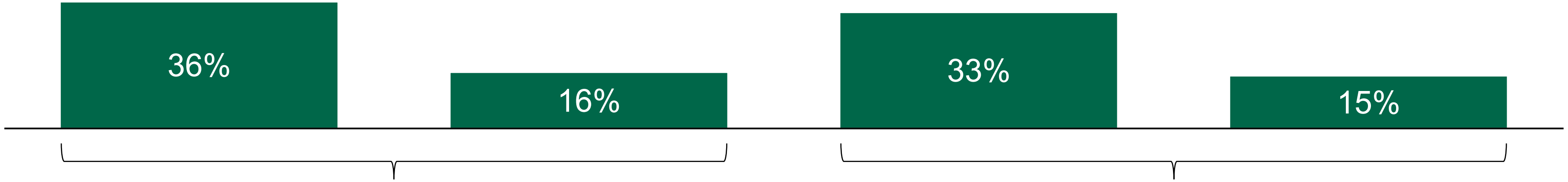
3


Mid density
Buildings <100 units

4


High density
Buildings >100 units

Share of streets



Prioritized containerization solution

Individual bins

Shared containers

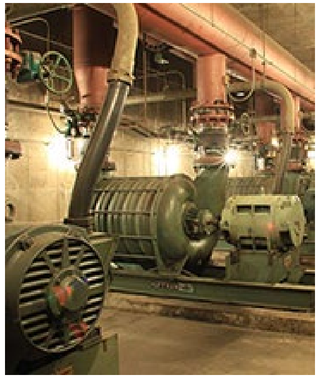
Containerization Model Evaluation, *cont.*

Containerization models that **are scalable** in New York City:

Containerization model		Applicability	Benefits	Considerations
Individual bin		• Single-family homes • <7 unit buildings *Currently used in Milan, Toronto, San Francisco, Chicago*	**Area covered:** ~93% of New York City residential properties are fewer than seven units (a total of 36% of residential units). **Limited behavior change:** Many residences already set out waste in individual bins, or store individual bins building-side before setout. **Lower streetscape impact:** Does not require permanent curb presence or loss to parking and other public needs. **Fleet compatible:** Can be mechanically collected using existing rear-loading fleet with a simple retrofit, instead of a net-new truck.	**Capacity:** Bins have a fraction of the capacity of larger shared containers (range from 16 – 65 gallons) and cannot be used for larger buildings. **Constraints on ease of collection:** Parked cars limit ability to maneuver bins for collection. **Post-collection disruption:** Bins improperly returned to properties post-collection have the potential to litter sidewalks and cause a new disruption to pedestrian flow. **Accessibility:** Some homeowners may need assistance bringing bins to the curb.
Stationary shared container		• 7+ unit residential buildings • Streets with sufficient available space *Currently in Singapore, Barcelona, Madrid, Paris, Buenos Aires, and more*	**High-density solution:** Provides a feasible solution for the 65% of New York City residential units (and 96% of Manhattan residential units) in 7+ unit buildings by using one to four cubic yard shared containers. **Central location:** Does not require the use of alleys or below-ground space and means waste does not need to sit in front of every property. **Collection efficiency:** Single point of collection means more waste can be collected in less time. **Snow compatible.**	**Impact on streetscape:** Requires substantial permanent curb presence (up to 25% of street). High potential for residential misuse and resulting eyesores. **Fleet overhaul:** Requires a new mechanized side-loading or hoist collection truck that does not currently exist at scale in the North American market; implications for longer roll-out timeline, expense, and fleet interoperability. **Frequency increase:** Certain high-density districts would require an increase in collection frequency to ensure a reasonable number of bins on the street. *London, England*

Containerization Model Evaluation, *cont.*

Containerization models that **are not scalable** in New York City:

Containerization model		Applicability	Benefits	Challenges and exclusionary factors
Underground or semi-underground container		High-density areas with available underground space *Currently used in The Hague, Amsterdam, Zurich*	**Significant capacity:** Partial or total storage allows for the accommodation of as much (or more) waste per container than above ground models. **Quality of life:** Impact to public space significantly reduced due to containers being hidden below street level; reduces vermin access to food source; reduces odors. **Technological capabilities:** Compactors and sensors can indicate when nearly full. **Seasonality:** No impact from snow for container collection (this solution is popular in high-snow urban areas).	**Requires underground space:** New York City underground infrastructure is complex and presents challenges for widespread roll-out; would require substantial interagency and public/private coordination over significant period of time. **Hoisted collection**: Lifting containers with hoists, required for below ground containers, would conflict with above-ground infrastructure (e.g., power lines, traffic lights, scaffolding, etc.,) and potentially poses a risk to pedestrian safety. **Streetscape access:** Requires ease of access during collection (e.g., no parked cars near opening during collection). **Speed:** Collection of each bin can take several minutes.
Pneumatic system		Areas with belowground authority and/or ease of coordination; greenfield areas (e.g., Roosevelt Island) *Currently in Singapore, Seoul*	**Nearly unlimited capacity:** Waste (that fits size parameters) is continuously and automatically transferred to central facility. **Impact on streetscape:** Minimal impact – no impact for chutes in high-rises, little impact for street-inlet system. **Seasonality:** No impact of snow for chutes.	**Underground infrastructure required:** Underground piping required to connect entrance to central facility(ies), which could conflict with existing infrastructure (as for underground containers) and require significant new infrastructure. **Limits given existing infrastructure:** Only cost effective to implement in new construction versus existing (e.g., even in Singapore, where 85% of population lives in high rises, only 5% have pneumatic systems given the model has been installed primarily in newer infrastructure). **Moderate behavior change:** Residents might only be able to dispose of smaller items (*i.e.,* typically <500mm wide) in pneumatic system; requires alternative options for bulk.

Viability Study

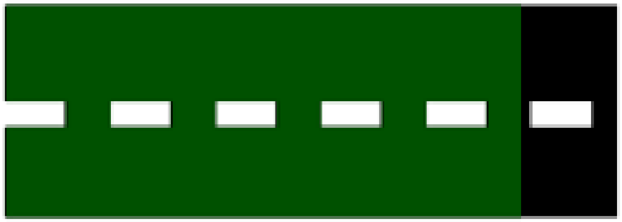
Viability – *Overview*

DSNY determined through careful analysis that containerization is viable citywide for 89% of New York City streets with residential properties, comprising 77% of the City’s total residential waste output.

All 89% of residential street sections can be containerized by eliminating up to 10% of current parking spaces citywide.

89%

of all residential streets



77%

of residential waste tonnage

Up to

10%

of parking spaces on residential streets

Viability – *Overview, cont.*

Viability is determined on a block-to-block basis, and assumes the following:

- ✓ Maximum of **25% of available curb space** (currently used as on-street parking or outdoor dining and does not include bus stops, protected bike lanes, or other existing hard constraints) can be reserved for shared containers.
- ✓ Containers must be able to hold **150% of current waste output** for each stream, per street length (based on frequency) to allow for future growth.
- ✓ **4 cubic yard shared containers** for *all* waste streams, except organics (which DSNY estimates requires a one cubic yard shared container).
- ✓ **Sufficient street width to accommodate shared containers –** 11 feet of roadway per driving lane and four feet of curb space per containerized side of the street.

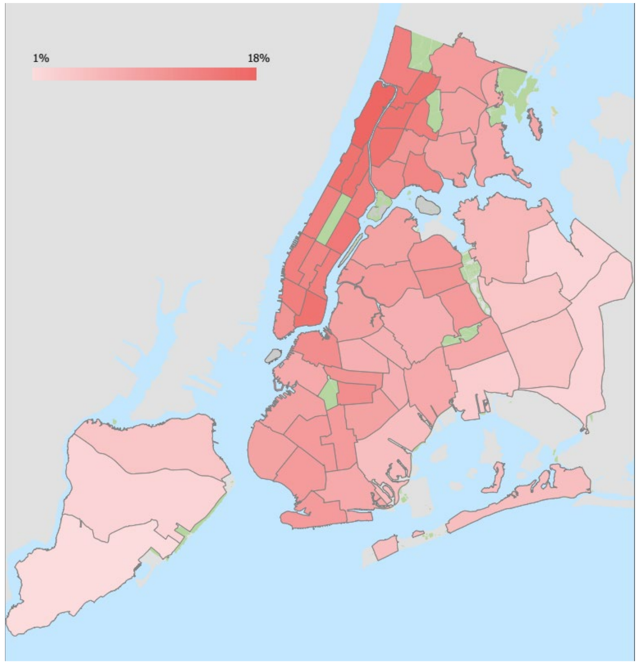
Two levers that could be pulled where needed to maximize viability:

- ✓ **Double collection frequency** (up to six days a week for refuse and two days a week for recycling and composting streams).
- ✓ **Additional changes to curb use**, for example by removing temporary structures to allow for stationary shared containers.

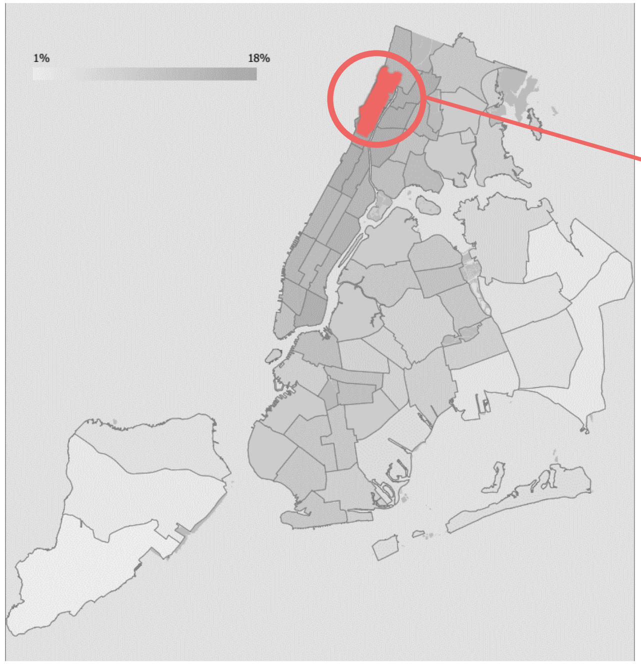
Viability – *Overview, cont.*

Of the estimated 1.5 million parking spaces located on streets with residential properties, stationary shared containers in the modeled citywide program (at four cubic yards each) would take up 10% of the total (~150,000 spaces). The requisite rebalancing of curb use is not equally borne across districts, as predominantly single-family and low-density neighborhoods using individual bins would not see any change, and there would be no impact to non-residential street sections.

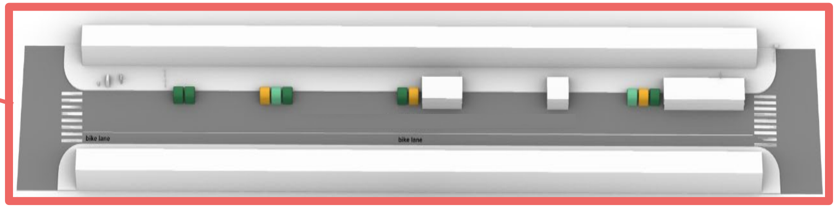
~150K total spaces… that's 10% of spaces on residential streets



Up to 18% of spaces in a district (e.g., Inwood)



No street would lose more than 25% of their curb space currently used for parking.



Map of percent of available parking needed to accommodate shared containers at 2x collection frequency, by sanitation district

Viability – *Overview, cont.*

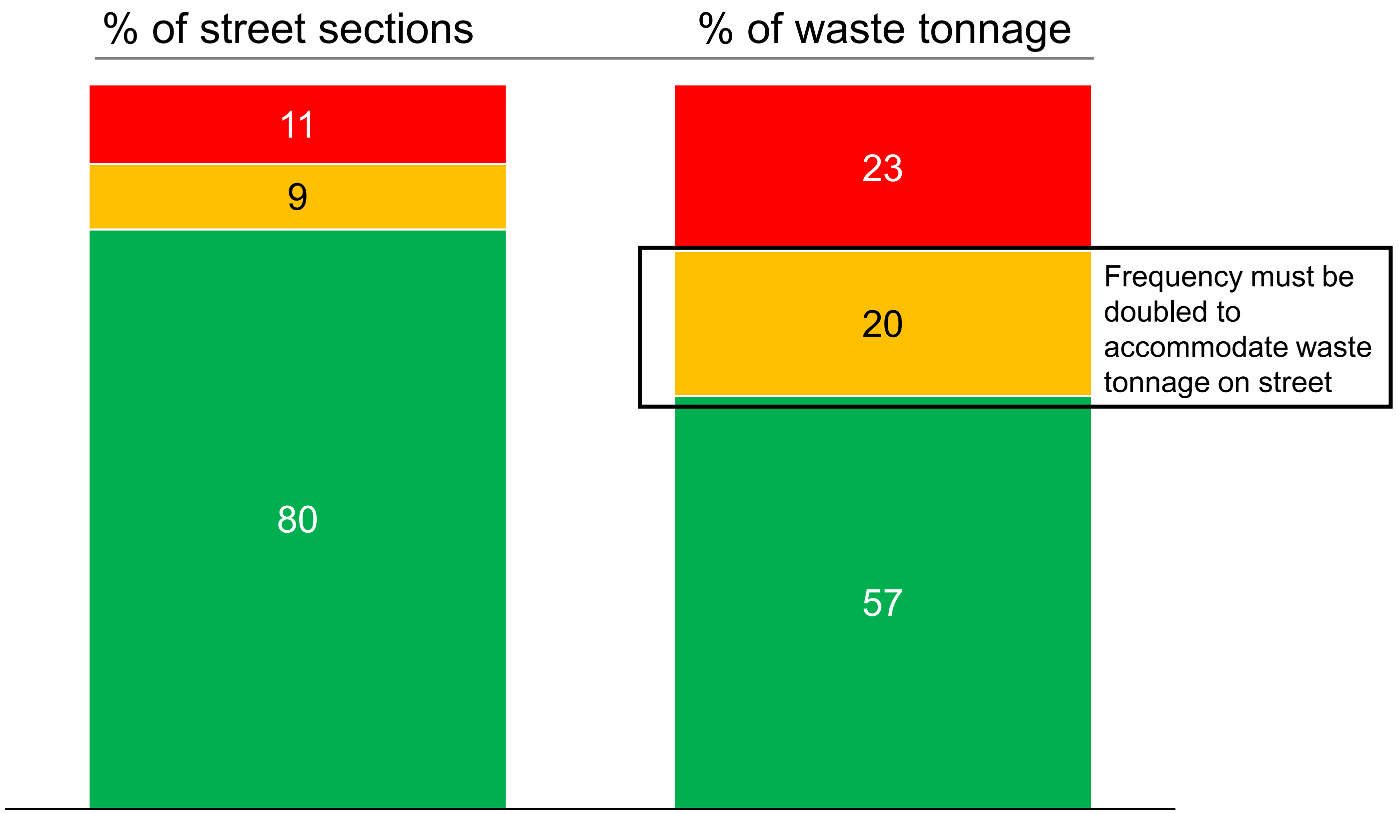
80% of the City's residential street sections can have a viable containerization solution without any changes to frequency. However, 9% of street sections (representing 20% of residential waste) require an increase of up to two times current collection frequency to achieve viability. The remaining 11% of residential streets produce an outsized volume of waste relative to available street area – a function primarily of density – and therefore no containerization model is currently viable, even with aggressive collection frequency increases. Within the 11%, streets may also not be viable for containerization due to other demands on the streetscape (e.g., bike lanes, bus lanes, loading zones, or throughways) or if streets are too narrow to accommodate shared containers on the curb.

"Viable" defined as containers would take up <25% of available street length.

C Viability not possible even with doubled collection frequency

B Viability requires doubled collection frequency

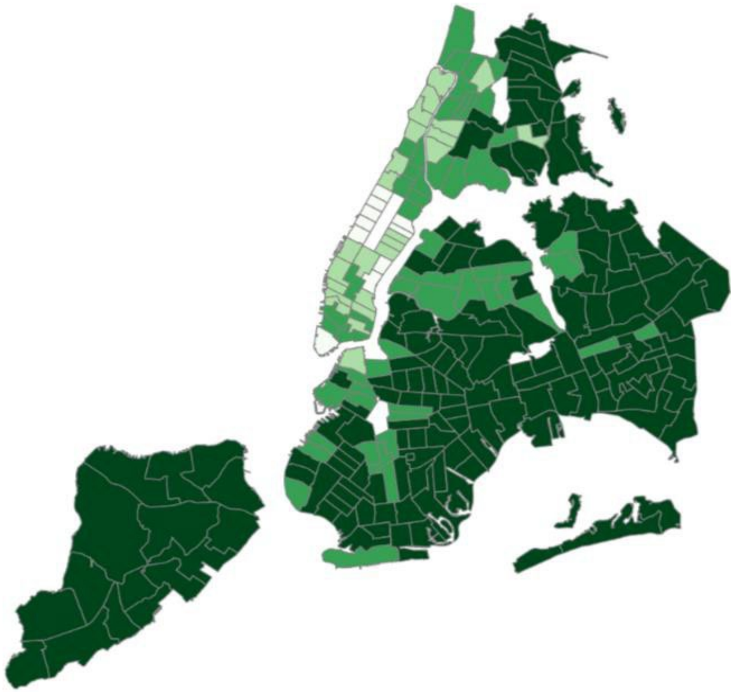
A Currently viable with no required change to collection frequency



Viability – *Overview, cont.*

Map A shows the areas where containerization is viable without any operational changes. This is inclusive of all street sections with predominantly 1-6 unit residences, which are by default marked as viable, as individual bins do not require any permanent presence on the curb. Maps B shows the distribution of the 9% of street sections where containerization requires an increase in pick-up frequency to be viable, and Map C shows the 11% of street sections where containerization is the most challenging. The non-viable street sections are heavily concentrated in high-density neighborhoods (e.g., the Financial District, Midtown West, and Downtown Brooklyn). The following pages illustrate what containerization looks like in each of these scenarios.

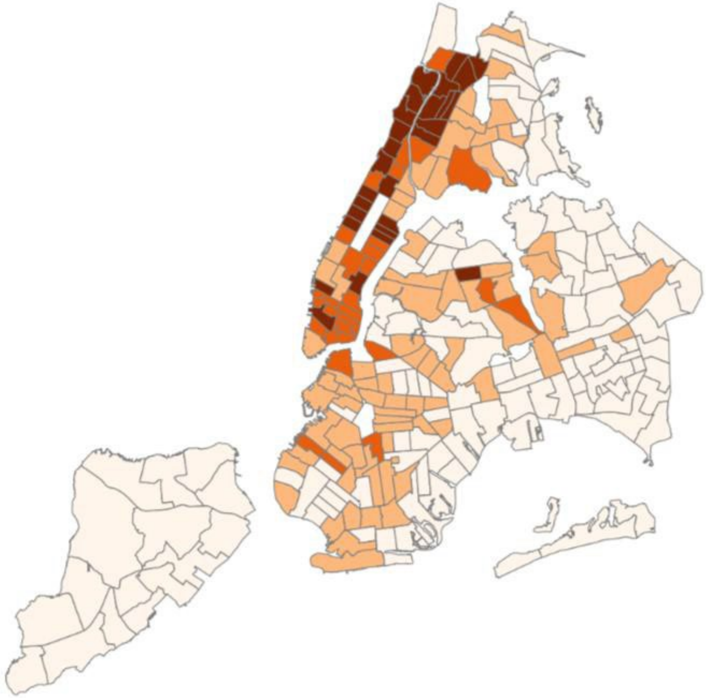
A Currently viable with no required change to collection frequency



Share of streets that require <25% of street length

- 75+% street sections
- 50-75% street sections
- 25-50% street sections
- 0-25% street sections

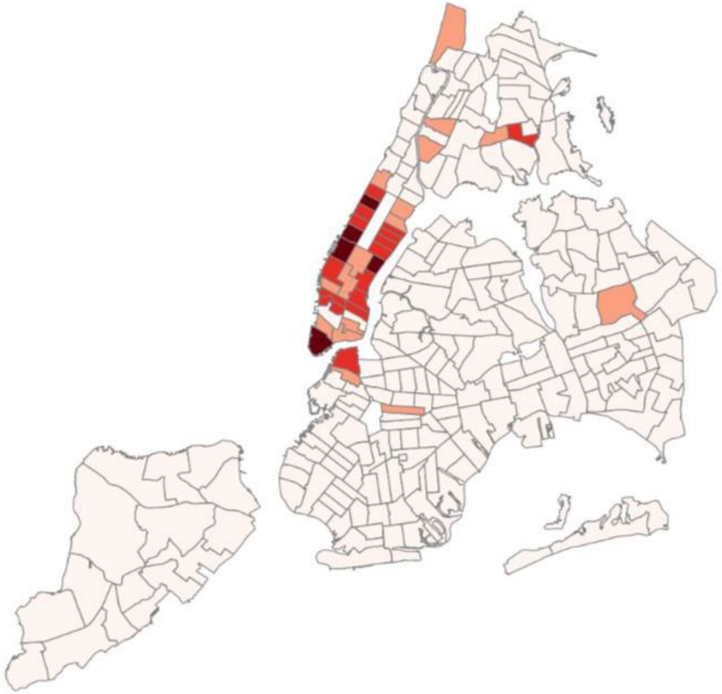
B Viability requires doubled collection frequency



Share of streets that require 25-50% of street length

- 30+% street sections
- 20-30% street sections
- 10-20% street sections
- 0-10% street sections

C Viability not possible even with doubled collection frequency



Share of streets that require >50% of street length

- 50+% street sections
- 30-50% street sections
- 20-30% street sections
- 0-20% street sections

Legend

Viability – *Street Sections That Require No Changes To Collection Frequency*

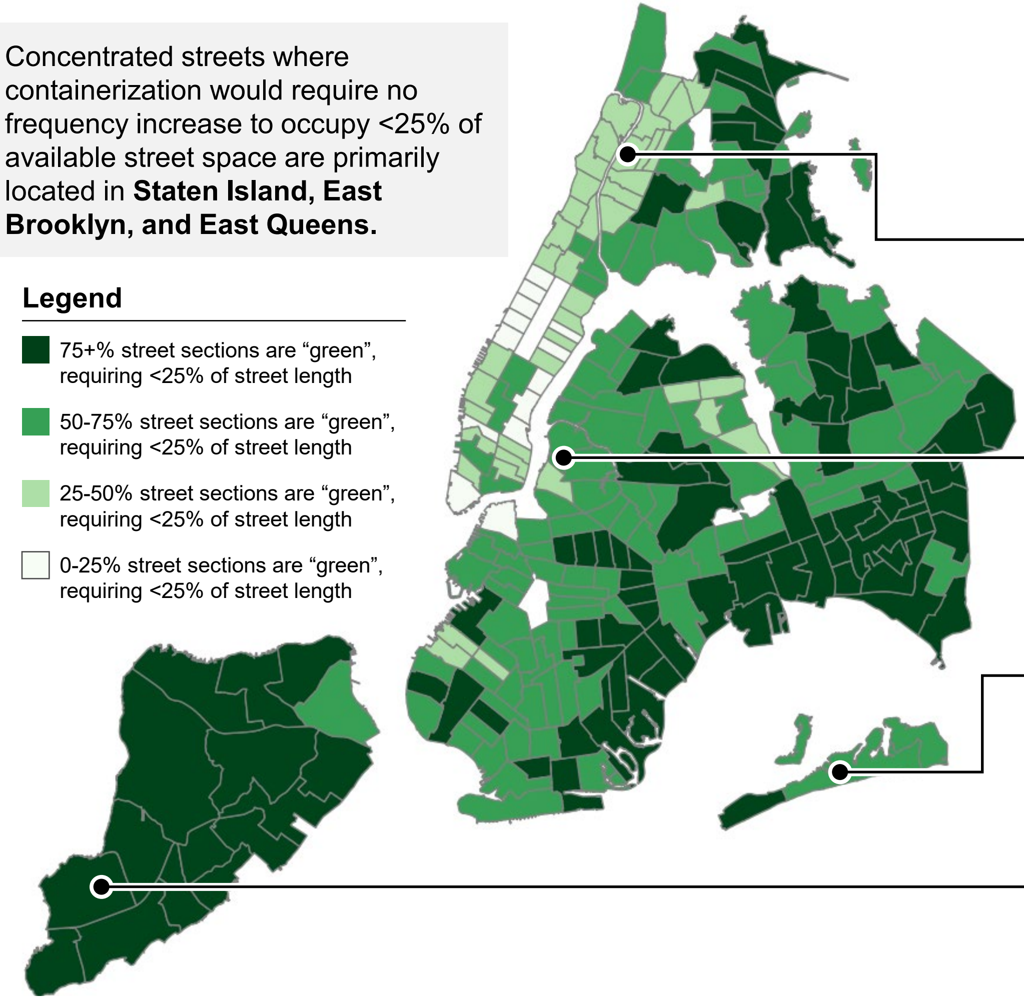
A

Deep dive: Containerization is viable on 80% of street sections, requiring <25% of street length, **assuming no change to collection frequency**. This includes all low-density street sections, which would use individual bins, and some mid-to-high density street sections, which would use shared containers. Examples of both cases are provided on the following two pages.

Concentrated streets where containerization would require no frequency increase to occupy <25% of available street space are primarily located in **Staten Island, East Brooklyn, and East Queens.**

Legend

- 75+% street sections are “green”, requiring <25% of street length
- 50-75% street sections are “green”, requiring <25% of street length
- 25-50% street sections are “green”, requiring <25% of street length
- 0-25% street sections are “green”, requiring <25% of street length



- **4161 – 4209 3rd Ave – West Bronx, Bronx**
- 339 units across 8 buildings (mixed 1-2 family, 1-6 story row houses, multi-family high-rise)
- ~90 – 115 yd^3 of waste / week
- Two-way street with parking on both sides

- **127 – 145 Bedford Ave – Williamsburg, Brooklyn**
- 56 units across 19 buildings (mixed 1-2 family)
- Generates ~17 – 23 yd^3 of waste / week
- One way street with parking on both sides

- **122-001 – 122-099 Beach Channel Dr – Rockaway, Queens**
- 6 units across 7 buildings (mixed 1-2 family)
- Generates ~5 – 6 yd^3 of waste / week
- Two-way street with driveways on residential side

- **650 – 678 Bloomingdale Rd – Rossville, Staten Island**
- 7 units across 6 buildings (mixed 1-2 family)
- Generates ~5 – 6 yd^3 of waste / week
- Two-way street with parking on both sides

Viability – *Street Sections That Require No Changes To Collection Frequency, cont.*

A

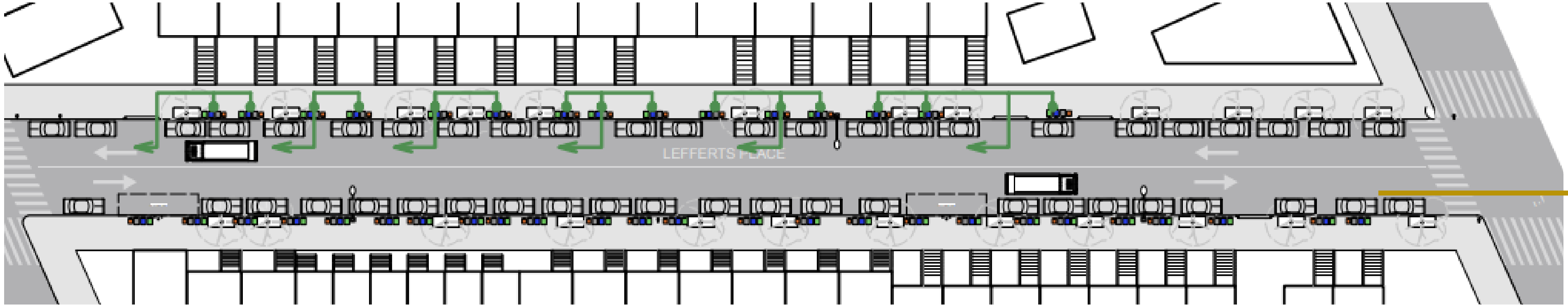
Example of individual bins on a low-density street segment in Brooklyn

176 individual bins would be set out by residents for collection, occupying zero parking spaces.

Residence Mix	Streetscape	Waste Generation				
44 buildings • 4 single family homes • 40 1-6 story row houses	• Two-way street • 590 ft total street length • 47 parking spaces • No protected bus or bike lanes		**Refuse**	**MGP**	**Paper**	**Organics***
		Frequency	3	1	1	1
		Yd^3 / week	35.4	8.2	14.4	.5
		Yd^3 / pickup	11.8	8.2	14.4	.5
		Individual bins (55g)	**44**	**44**	**44**	**44**

Note: Sanitation workers roll individual bins to the nearest egress for collection.

Path taken by DSNY workers

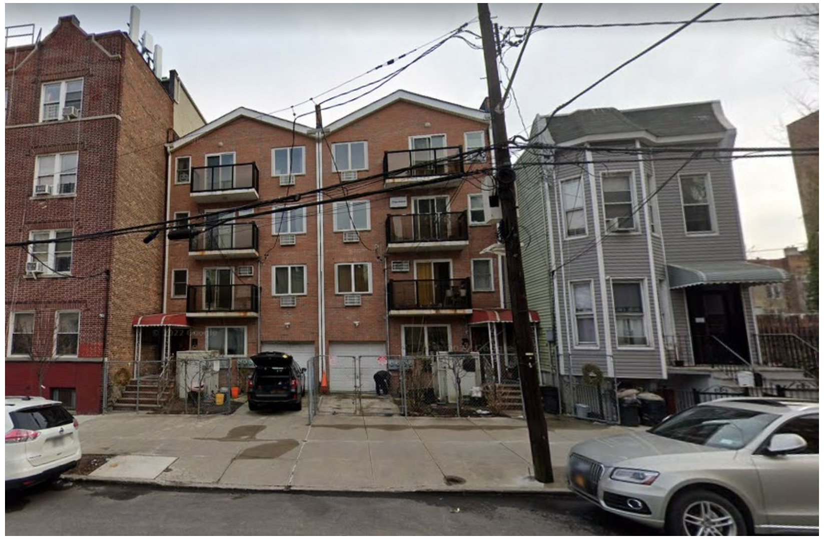


Viability – *Street Sections That Require No Changes To Collection Frequency, cont.*

A

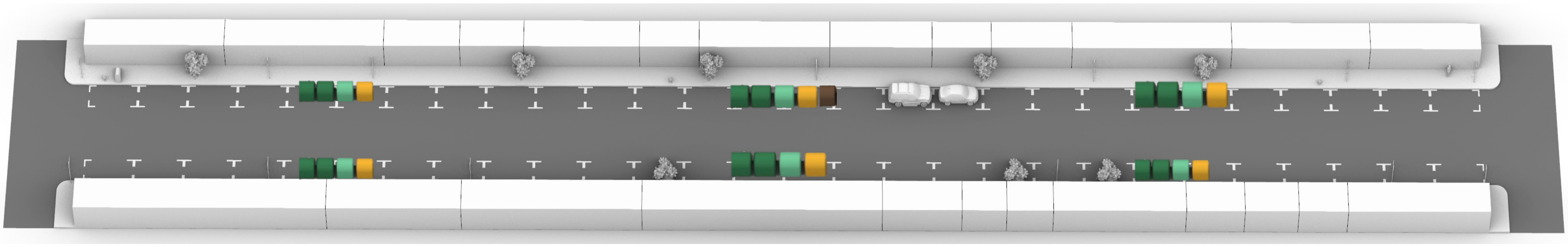
Example of shared containers on a mid-density street section in The Bronx

25 shared containers would occupy 11.5 parking spaces (24% of total spaces currently available)



Residence Mix	Streetscape	Waste Generation
236 units across 29 buildings • 12 1-2 family homes • 9 1-6 story row houses • 8 multistory buildings with 10-50 units	• Two-way street • ~640 ft in total street length • 48 parking spaces • Bus stop • No protected bus lane	see below

	Refuse	MGP	Paper	Organics*
Frequency	3	1	1	1
Yd^3 / week	135	22	22	1
Yd^3 / pickup	45	22	22	1
4 yd^3 container	**12**	**6**	**6**	**1**



Viability – *Street Sections That Require Doubled Collection Frequency*

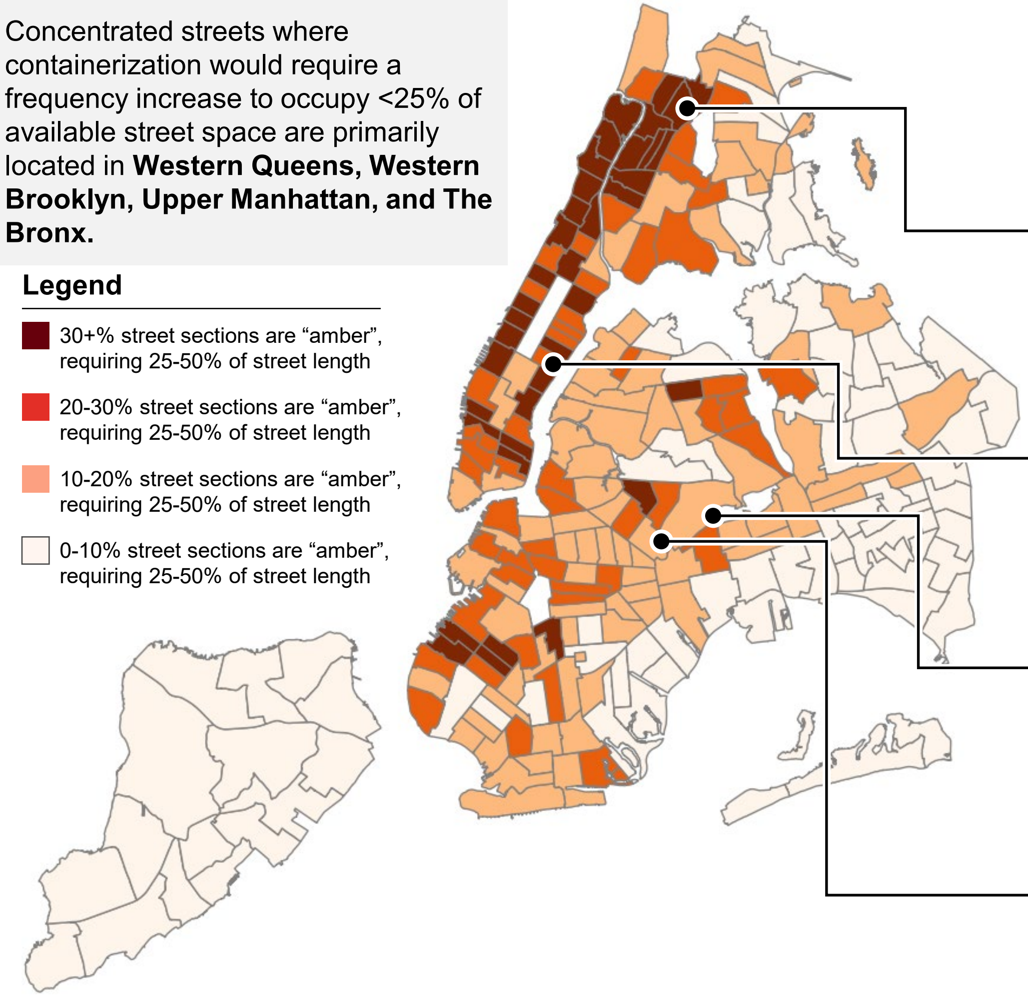
B

Deep dive: Containerization is viable on an additional 9% of street sections representing 22% of residential waste, requiring <25% of street length, **assuming collection frequency is doubled**. This includes only mid-to-high density street sections that use shared containers. An example of this case is provided on the following page.

Concentrated streets where containerization would require a frequency increase to occupy <25% of available street space are primarily located in **Western Queens, Western Brooklyn, Upper Manhattan, and The Bronx.**

Legend

- 30+% street sections are “amber”, requiring 25-50% of street length
- 20-30% street sections are “amber”, requiring 25-50% of street length
- 10-20% street sections are “amber”, requiring 25-50% of street length
- 0-10% street sections are “amber”, requiring 25-50% of street length



- **3201 – 3299 Olinville Ave – Olinville, Bronx**
- 272 units across 48 buildings (mixed 1-2 family, 1-6 story row houses)
- Generates ~130 – 160 yd^3 of waste / week
- One way street with parking on both sides

- **201 – 299 E 62nd St – Lenox Hill, Manhattan**
- 301 units across 48 buildings (mixed 1-2 family)
- Generates ~80 – 100 yd^3 of waste / week
- One way street with parking on one side

- **85-001 – 85-099 95th Ave – Ozone Park, Queens**
- 33 units across 21 buildings (mixed 1-2 family)
- Generates ~25 – 30 yd^3 of waste / week
- One way street with parking on both sides

- **87 – 147 Euclid Ave – Cypress Hills, Brooklyn**
- 139 units across 40 buildings (mixed 1-2 family, 1-6 story row houses, multi-story 50-150 units)
- Generates ~110 – 130 yd^3 of waste / week
- One way street with parking on both sides

Viability – *Street Sections That Require Doubled Collection Frequency, cont.*

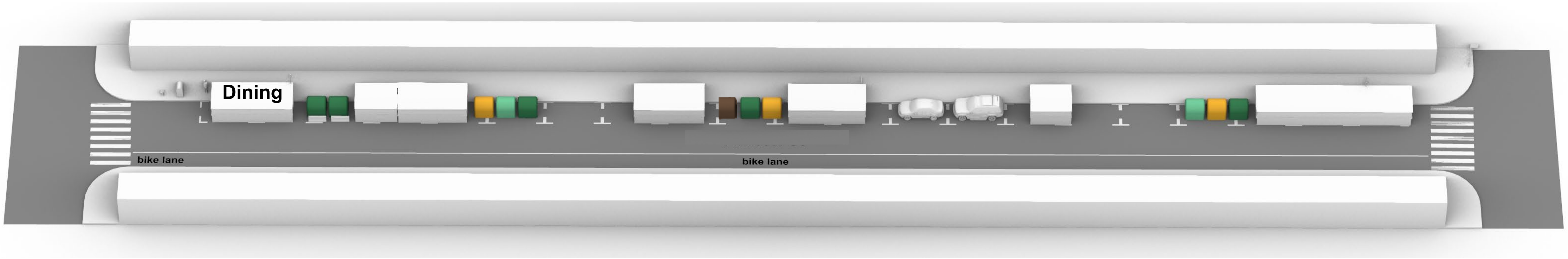
B

Example of shared containers on a mid-density street section in Manhattan, assuming double collection frequency

11 shared containers occupy 3.5 parking spaces (17% of total, *not including outdoor dining;* 39% with no changes to outdoor dining)

Residence mix	Streetscape	Waste generation and collection				
324 units across 21 buildings • 5 1-6 story row houses • 16 multi-story buildings with 10-50 units	• Two-way street • ~450 ft in total street length • 21 parking spaces *(12 currently occupied by outdoor dining)* • Unprotected bike lane		**Refuse**	**MGP**	**Paper**	**Organics***
		Frequency	**6**	**2**	**2**	**2**
		Yd^3 / week	100	13	22	1
		Yd^3 / pickup	17	7	11	0.5
		4 yd^3 containers	**5**	**2**	**3**	**1**

Note: Containerizing this street section also could require the removal of some outdoor dining structures currently in place.



Viability – *Street Sections That Are Not Viable (Even With 2X Collection Frequency)*

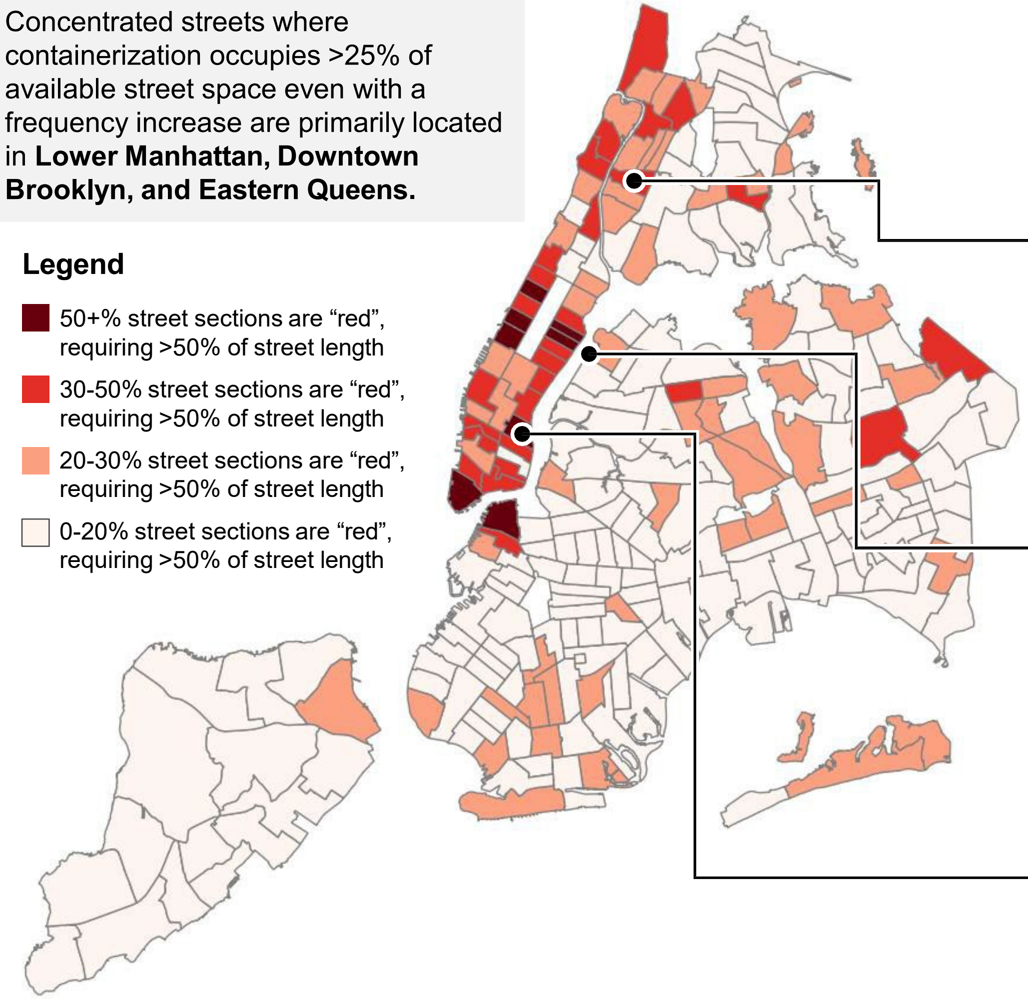
C

Deep dive: Containerization is not viable on 11% of street sections, where it would require 50% - 150% of street length; **doubling collection frequency does not brings these streets under the viability threshold**. This includes only mid-to-high density street sections that use shared containers. An example of this case is provided on the following page.

Concentrated streets where containerization occupies >25% of available street space even with a frequency increase are primarily located in **Lower Manhattan, Downtown Brooklyn, and Eastern Queens.**

Legend

- 50+% street sections are "red", requiring >50% of street length
- 30-50% street sections are "red", requiring >50% of street length
- 20-30% street sections are "red", requiring >50% of street length
- 0-20% street sections are "red", requiring >50% of street length

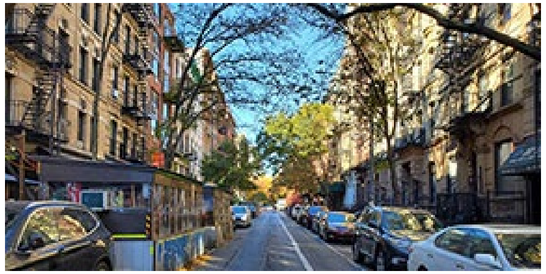


Examples where containerization solution could take >50% of street length, assuming "as is" operations

- **531 – 549 E 173rd St – Claremont, Bronx**
- 286 units across 4 buildings (1-6 story rowhouse, high-rise)
- Generates ~70 – 90 yd^3 of waste / week
- One-way street with parking on both sides

- **25-001 – 25-057 12th St – Astoria, Queens**
- 422 units across 9 buildings (mixed 1-2 family, 1-6 floor rowhouse, high-rise)
- Generates ~90 – 130 yd^3 of waste / week
- One-way street with parking on both sides

- **201 – 243 E 10th St – Ukrainian Village, Manhattan**
- 792 units across 36 buildings (1-6 floor rowhouse, high-rise)
- Generates ~275 – 330 yd^3 of waste / week
- One-way street with parking on both sides



Viability – *Street Sections That Are Not Viable (Even With 2X Collection Frequency), cont.*

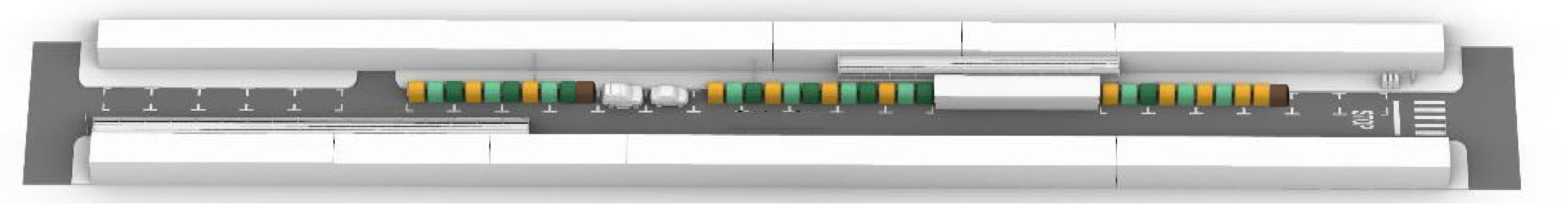
C

Example of shared containers on a high-density street section in Manhattan, assuming double collection frequency

32 shared containers occupy 13 parking spaces (50% of total, not including outdoor dining; 57% with no changes to outdoor dining)x

Residence mix	Streetscape	Waste generation and collection				
1,329 units across 4 buildings • 1 multi-story units with 50-150 units • 3 large high-rise residential buildings 150+ units	• One-way street • ~550 ft in total street length • 26 parking spaces *(3 currently occupied by outdoor dining)*		**Refuse**	**MGP**	**Paper**	**Organics***
		Frequency	**6**	**2**	**2**	**2**
		Yd^3 / week	180	78	90	4
		Yd^3 / pickup	30	39	45	2
		4 yd^3 containers	**8**	**10**	**12**	**2**

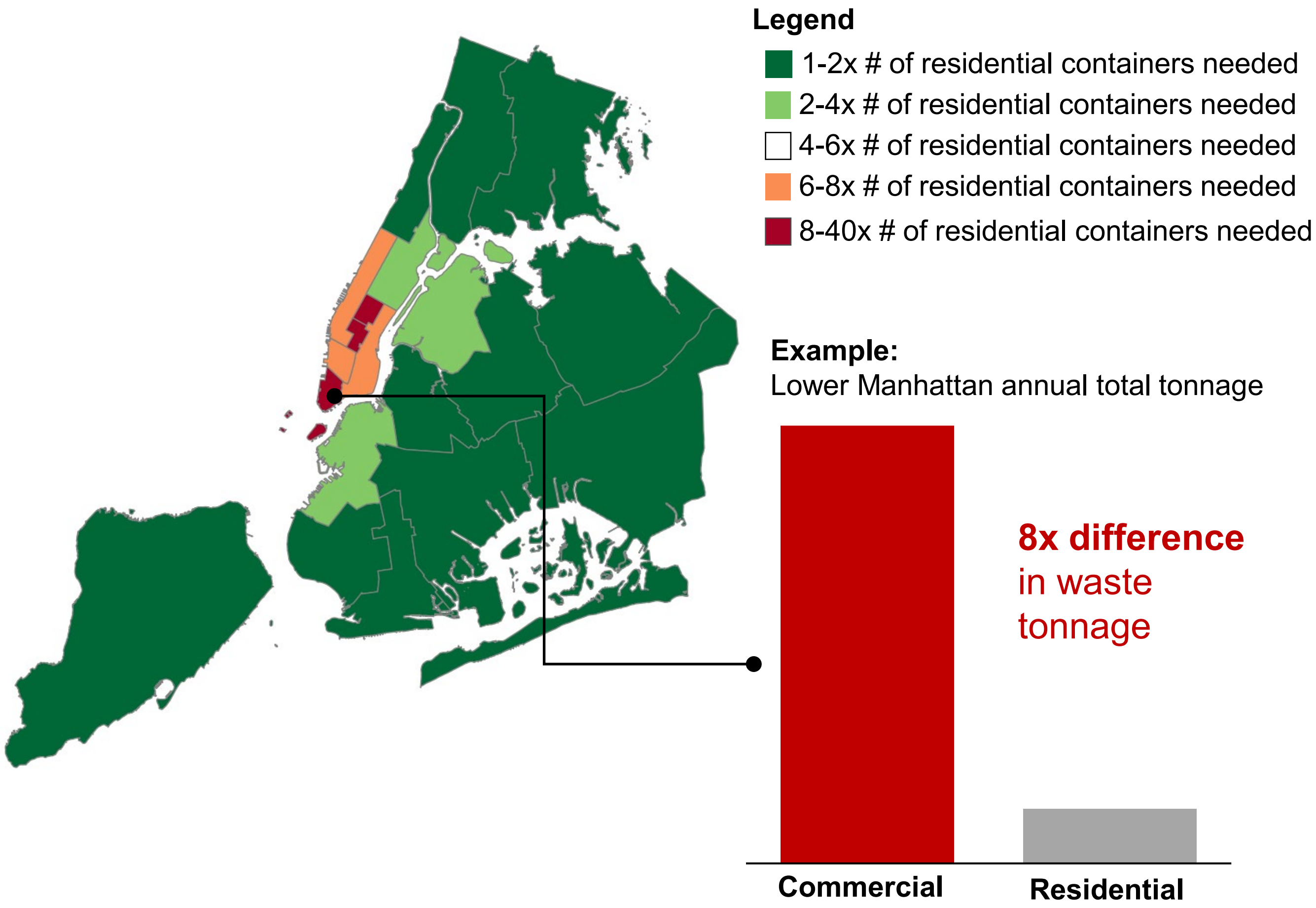
**The street section examined does not currently have curbside organics collection; tonnage estimated using citywide average.*



Viability – *Commercial Corridors*

Commercial waste accounts for more than half of the 44 million pounds of waste discarded in New York City. However, containerizing commercial waste is not viable in most high-density business districts for two reasons:

1. The overlapping network of private carters and tonnage-based fee system – even in the new framework established by the Commercial Waste Zones law – makes shared containerization impossible.
2. In dense business districts like lower Manhattan, the commercial waste tonnage is eight times greater than the residential waste tonnage, and requires up to 40 times the number of shared containers. This is an impossible amount of waste to containerize on the street.



Operational and Design Considerations

Wheeled Shared Containers

Wheeled shared containers are not a reliable, scalable solution for New York City. However, they are compatible with current fleet and present an opportunity to meaningfully pilot shared containerization.

Benefits

Fleet compatibility: Wheeled shared containers are compatible with existing rear-loading fleet (with retrofits), and have been used by other cities as an interim step towards a stationary shared container solution.

Timeline: The implication of fleet compatibility is that wheeled shared containers can be implemented on a significantly faster timeline than stationary shared containers, making them optimal for early-rollout pilot programs.

Drawbacks

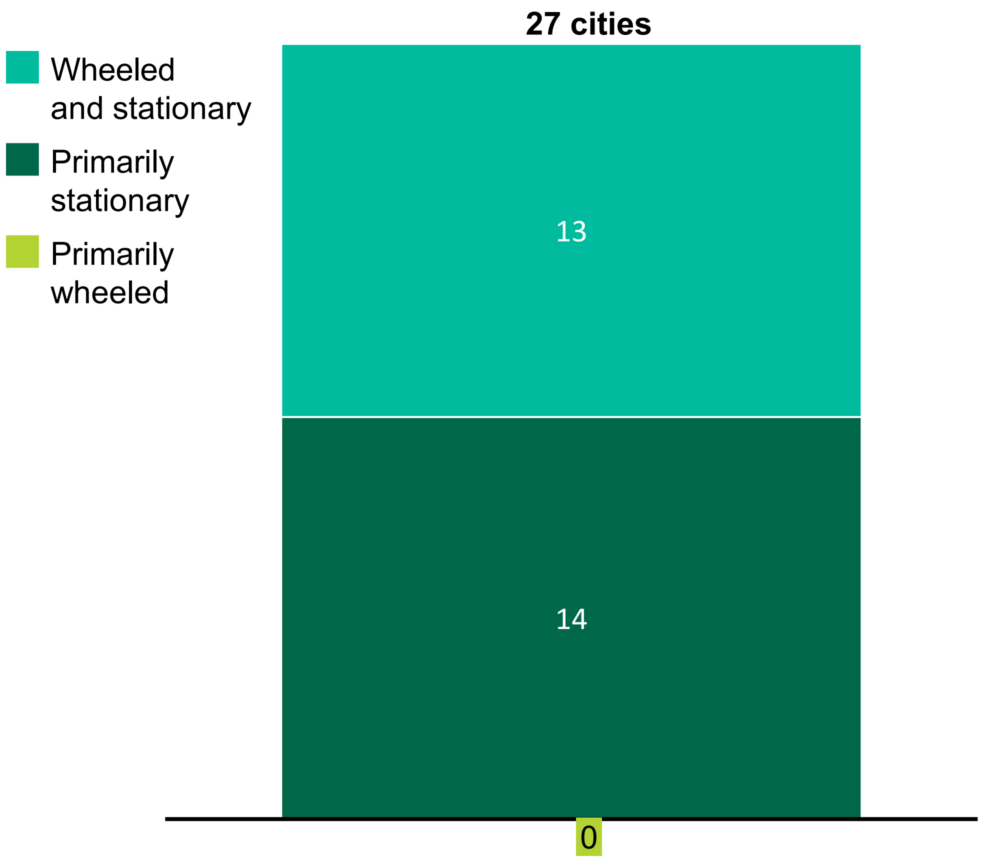
Public misuse: Because wheeled shared containers are not secured to the street, unlike stationary shared containers, they can be moved without authorization. The use of a locking mechanism would significantly slow down collection efficiency.

Collection obstructions: Collection of wheeled shared containers can be hampered by obstructions in the street, including: potholes, uneven pavement, loose refuse, snow and ice, etc. By comparison, stationary shared containers are collected via hydraulic arms that can break ice and lift over snow.

Durability and repairs: Wheeled shared containers are highly prone to breakage due to concentrated impact on the four corners where wheels connect to the container, particularly when bearing significant weight loads and being used for daily collection. Annual maintenance is higher per container due to significant preventative maintenance needs associated with wheels; at three years, a large wheeled container's expected useful life is less than half that of a stationary shared container.

Wheeled Shared Containers, *cont.*

Of 27 surveyed cities with shared container systems, no city prioritized wheeled shared containers as the primary containerization solution; however, half of all containerized cities use wheeled containers (individual or shared) as part of the solution.



Stationary shared containers are more durable, can be collected reliably without obstruction, have a higher capacity, and do not have risks of public misuse. However, fleet overhaul requirements for stationary shared containers would delay any implementation by at least three to five years. Wheeled shared containers are thus a viable option for short-term containerization pilots, but not long-term scaled design.

	Wheeled	Stationary
Lifetime	3 years	8-11 years
Capacity	Wheeled has 10-20% less capacity	
Collection obstruction	Wheeled has higher exertion in unlock, rolling and clearing Wheeled less reliable as overground rolling path to truck may be obstructed	
Public misuse	Risk of unauthorized movement of containers	N/A
Durability and repairs	Wheeled containers are more prone to damage and have a higher down rate	Fleet have side-lifting or hoist arms that require additional maintenance
Fleet compatibility	Compatible with existing rear-loader fleet (with retrofits)	Requires net-new mechanized truck with a side-lifting or hoist mechanism
Timeline	Could be implemented in New York City relatively quickly	New truck development delays rollout by 3-5 years

Fleet Model for Stationary Shared Containers

Stationary shared containers can be serviced by two fleet models: automatic side loaders (ASLs) or hoist trucks. **DSNY's strongly preferred fleet model is the ASL.**

DSNY's assessment is that the hoist truck is not viable for scaled deployment in New York City for three reasons:

1. Untenable safety risks associated with suspending containers above cars and pedestrians for minutes at a time on high-density streets.
2. Many city streets do not have the 20 feet of overhead clearance space required to collect with a hoist.
3. Hoist trucks cannot handle loose bags placed around containers, requiring a second truck to pass the same block to collect any remaining bags.

While some ASLs exist in the U.S., the current designs are not fit for collecting stationary shared containers in dense urban environments. As shown on the next page, ASLs are commonly used to collect individual bins in suburban and rural areas, but these designs cannot be used for containers larger than the typical 96-gallon suburban waste container for individual households.

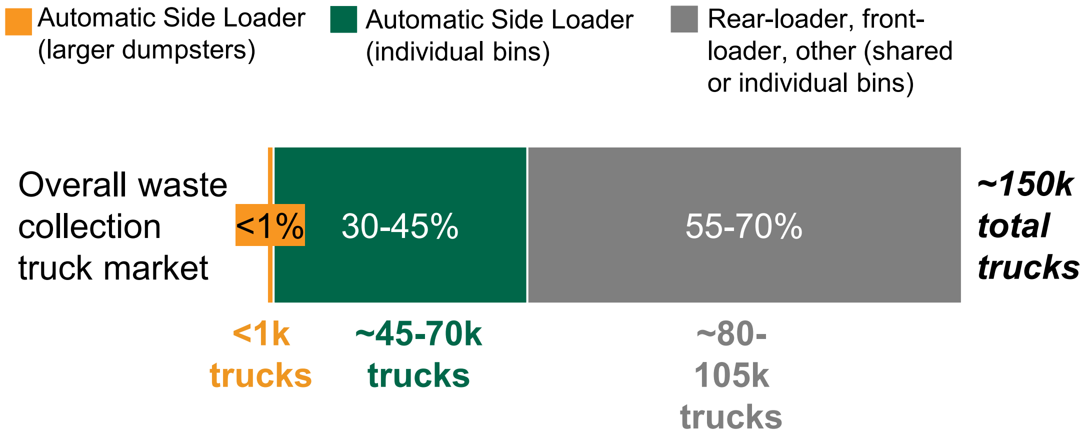
The existing North American ASL market for larger dumpsters is tiny, and these are almost entirely deployed in the private sector to service common metal dumpsters sited off-street. These dumpsters are primitive, prone to rust and breakage, and not sufficiently accessible for at-scale use in New York City. Moreover, lifting and emptying common metal dumpsters overhead is extremely loud and would be unacceptable for residential neighborhoods because dumpsters weighing hundreds of pounds bang against the trucks and crash back to the ground on each pickup.

European ASLs, purpose built for lightweight, on-street stationary shared containers, are the only viable strategy at scale, but they do not meet federal, state, and local emissions and safety standards so they cannot be imported for domestic use. **A scalable, viable truck for shared container collection in New York City does not currently exist in the United States.**

Accordingly, DSNY must work with industry to develop a first-of-its-kind ASL collection truck for stationary shared containers in the United States. This would take at least three years and significant capital investment.

Fleet Markets

North American collection truck market



North America predominantly uses ASLs to service individual bins, but Europe has continued to innovate, including with ASLs for shared containers at scale

European collection truck market

Shared container side-loaders: *Estimated adoption rate for select cities*

Madrid:	Rome:	Valencia:	Lisbon:	Milan:
~70%	~70%	~70%	~10%	~10%

ASL market penetration is expected to remain steady or continue to increase over time.

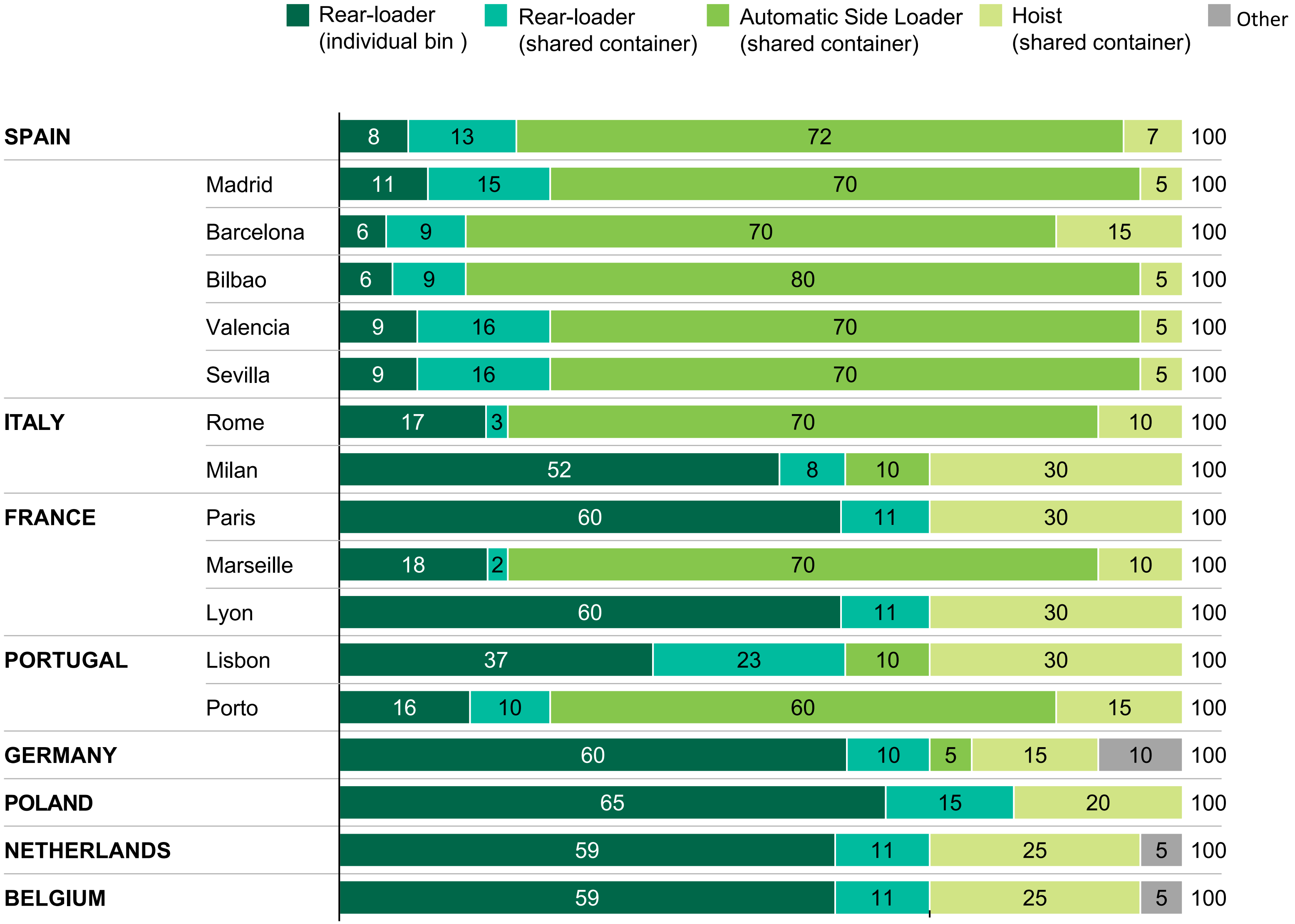
Experts have not observed reversion from shared container side-loading programs in any European or Latin American cities.

Fleet Markets, *cont.*

Most containerized cities deploy a mixture of fleet options to service different areas, based on archetype and need.

ASLs are the primary fleet model in many stationary shared container systems, including Madrid, Barcelona, Rome, and Marseille. Cities that deploy the hoist truck in higher percentages are typically lower density, which is reflected in the corresponding higher percentage use of rear-loaded individual bins.

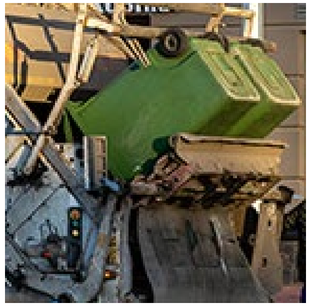
No major city assessed in this study uses wheeled shared containers as their primary, or even secondary, containerization model.



Fleet Standards

	Consideration	
Regulatory standards	**Emissions**	The truck engine must be compliant with U.S. Government, New York State, and New York City Emissions regulations. Trucks must meet the U.S. Environmental Protection Agency (EPA) standard at the point of manufacture in order to be approved for public road use or be recertified by an importer, a complicated process not generally used for on-road heavy-duty equipment. [1] Instead, any foreign truck would have to be re-designed in partnership with a U.S. based company or as part of an American manufacturing operation of a foreign-owned company.
	Safety features	Trucks used in the U.S. must comply with the Federal Motor Vehicle Safety Standards (FMVSS) issued by the National Highway Traffic Safety Administration. Unless a vehicle is manufactured in the U.S. or is manufactured abroad and is certified by the manufacturer as conforming to the FMVSS, it cannot be used in the U.S.[2]
	Compatibility	European and American trucks are designed using different standards for hydraulic, electrical, and computing systems, along with different standards for axle loading and weight rating, make adapting European truck bodies to American chassis a complicated engineering challenge, requiring significant modification and adaptation.[3]
	Noise level	According to the New York City Noise Code, *"maximum sound levels may not exceed 80 decibels between the hours of 11:00 pm and 7:00 am within 50 feet of a residential property when measured at a distance of 35 feet or more from the vehicle when the compactor is engaged."*[4] ASLs may result in a higher noise level when lifting, tipping, and putting down containers. Currently-available commercial side loaders in the U.S. are designed to lift 1-4 cubic yard steel commercial containers in alleys or other off-street areas; these are extremely noisy as-is and cannot be used near residential properties. DSNY must partner with truck and container manufacturers reduce noise during collection by using highly-durable, non-metal containers, among other noise-reduction strategies.
Operational Requirements	**Snow plow and turning radius**	All refuse trucks must be enabled for plowing and piling of both snow and ice and will be required to plow snow when either fully loaded or empty. In general, ASLs have a longer wheelbase, given the area occupied by the lifting and compacting mechanism in the center of the vehicle. These also have a wider turning radius that would be increased further by the addition of a snowplow.. In general, ASLs have a longer wheelbase, given the area occupied by the lifting and compacting mechanism in the center of the vehicle. These also have a wider turning radius that would be increased further by the addition of a snowplow.
	Wheelbase, max. height and width	Standards are set by DSNY in order to ensure that trucks can drive down and turn on a diverse set of New York City streets, enter and exist DSNY garages, and fit within garages for storage. Width must not exceed 102" at widest point; Height must not exceed 11'5"; vehicle wheelbase must not exceed 173"; complete vehicle length (without plow) must not exceed 34'.

Summary of Fleet Options

Containerization model		Fleet Compatibility		Scaled Regional Avail.	
Individual bin		Rear-loader with retrofit		YES	• **Service time:** <1 min; can unload two bins at once • **Mechanization:** 1-2 simple tippers in rear • **Disruption to current state**: Retrofit (limited downtime) • **Ability to service both sides of the street:** Yes • **Loose bag and bulk interoperable**: Yes (both)
Stationary shared container		Automatic Side-Loader		NO	• **Service time:** < 1.25 min • **Mechanization:** 1 hydraulic arm • **Disruption to current state**: New fleet required • **Ability to service both sides of the street:** No • **Loose bag and bulk interoperable**: Yes (loose bag only)
		Hoist		NO	• **Service time:** < 2.25 min • **Mechanization:** hopper extension and crane • **Disruption to current state**: New fleet required • **Ability to service both sides of the street:** Yes (requires 20 feet of overhead clearance) • **Loose bag and bulk interoperable**: No (both)
Wheeled Shared Container		Rear-loader with retrofit		YES	• **Service time:** <2 min • **Mechanization:** 1 simple tipper in rear • **Disruption to current state**: Retrofit (limited downtime) • **Ability to service both sides of the street:** Yes • **Loose bag and bulk interoperable**: Yes (both)

Pathway to Containerization

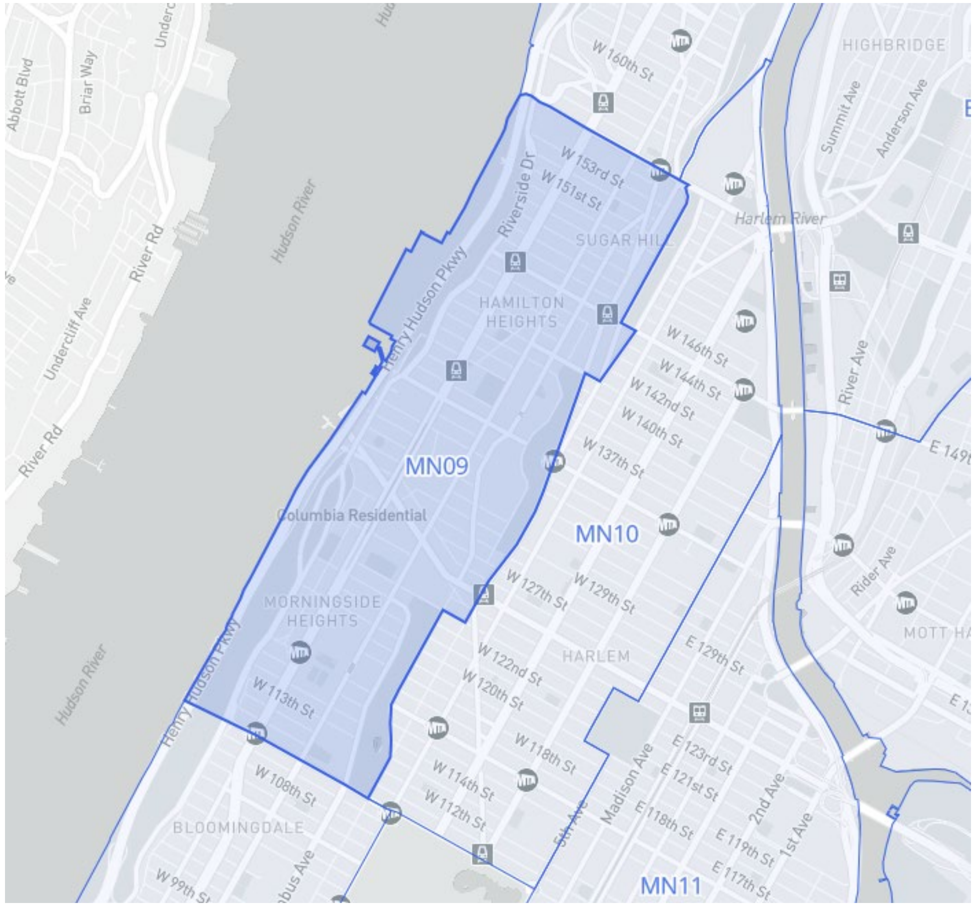
Pathway to Containerization

		Immediate next steps *(detailed in the next section)*	**Future vision**
Residential	 	• Conduct a rapidly deployed pilot of wheeled shared containers serviced by retrofitted existing collection trucks.	• Develop a first-of-its-kind stationary shared container and associated collection truck suitable for scaled use in a dense urban environment in the United States. • Work with stakeholders through the City's rulemaking process to explore requiring households in lower-density areas not fit for stationary shared containers to use individual bins.
Institutional		• Conduct a rapidly deployed pilot of wheeled containers at multiple schools serviced by retrofitted existing collection trucks.	• Expand wheeled containers to all New York City public school buildings and other public institutions.
Commercial	 	• Work with stakeholders through the City's rulemaking process to explore requiring businesses in industries that produce a significant amount of putrescible waste to use individual bins.	• Work with stakeholders through the City's rulemaking process to explore requiring other businesses to use individual bins. • Expand off-street containerization in large commercial buildings by incentivizing or requiring new large commercial developments to include loading docks.

Immediate Next Steps

DSNY is planning the first large-scale pilot of mechanized collection of shared containers in New York City. This pilot will include deployment of large wheeled containers on up to 10 residential blocks and at schools in Manhattan Community Board 09 (“MN09”).

This is a critical opportunity to stress test containerization in a real-world setting for residents and institutions. Wheeled shared containers are not being put forward as a residential solution beyond this pilot. The results of this pilot will provide critical information required for future expansion.

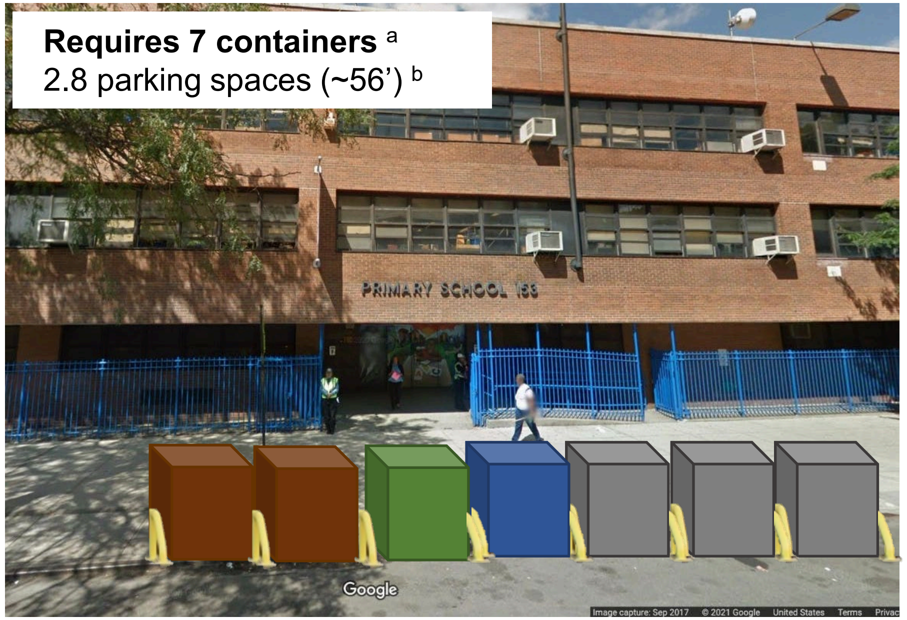


Residential and Institutional, *cont.*

SCHOOLS	RESIDENTIAL
• Pilot will address up to 14 public school buildings in MN09. • Three yd^3 (606 gallon) wheeled shared containers for all waste streams will be placed permanently in the parking lane outside of schools, each taking up ~8 feet. Total number of containers will be determined by existing waste tonnage for each school. • Collection will occur daily for all streams using a standard rear-loader collection truck retrofitted with mechanized tippers.	• Pilot will address up to a 10-block zone with predominantly 7+ unit buildings in MN09. • Three yd^3 (606 gallon) wheeled shared containers for all waste streams will be placed permanently in the parking lane on each street section in the pilot, each taking up ~8 feet. Total number of containers will be determined by existing waste tonnage for each block. • Collection will occur daily for all streams using a standard rear-loader collection truck retrofitted with mechanized tippers.

EXAMPLES

Density: *540 students*
Weekly waste (yd^3): *30 refuse / 1.5 MGP / 8.5 paper / 24.3 organics*



[a] Assumes 125% waste volume and equal distribution of weight across days.
[b] DOT defines each parking space as 20 feet of curb length and this estimates assumes each container occupies 8 feet of curb length.

Density: *21 units on 5 floors*

Commercial

DSNY rules currently incentivize businesses to use containers by allowing all commercial establishments that use containers to set out their waste and recyclable materials before 8 pm.

Going one step further and requiring businesses to place their trash in sealed containers would limit food sources for rats.

To that end, DSNY will work with stakeholders representing industries that produce a significant amount of food waste to explore requiring the use of individual bins through the rulemaking process.

Appendix

Methodology

Methodology

To conduct an accurate assessment of citywide current viability, all residential buildings were mapped to street sections, waste generation was converted from tonnage to volume, and real available streetscape space was determined by subtracting the area of current on-street hard constraints (e.g., bus lanes, bike lanes) from the total street section area.

Street sections (a single block on a street between two intersections and/or termini) were categorized into archetypes, which entails validating an initial top-down approach with granular bottom-up analysis using land use and residential units data by building, matching buildings to street sections, calculating building type share for all street sections, and then categorizing street sections into archetypes. Because the block face where waste is currently set out for buildings touching multiple street sections is up to the operational discretion of the individual buildings, a conservative assumption of “maximum distribution” was applied evenly across the dataset, which assumes that for buildings touching multiple street faces, the setout could potentially occur on any of them.

Converting waste from tonnage to volume was done based on EPA guidelines and preliminary learnings from DSNY’s Multi-Unit Building Study; the precise volume conversion is not known, given that there is no holistic dataset on the use of in-building cardboard balers and waste compactors. Conservative estimates were used as a precaution.

Study Focus: Residential Waste

Current analysis is focused on potential containerization solutions for residential waste only, on street segments with residential properties:

- Total residential waste accounts for **~41% of total waste** generated in New York City.
- There are approximately **69,000 total residential street sections** in New York City.

Viability Study Assumptions

- **Container size:** 4 cubic yards per container
- **Available curb space:** 25% maximum of available street space occupied
- **Sufficient street width:** 11ft of roadway (per driving lane) and 5 feet of curb space per containerized side of the street.

Fact Base to Assess Containerization Potential

Mapping of all resident buildings to streets

Merge 3 databases to enable mapping of residences to sidewalks to street sections:
1. MapPLUTO (2022); 2. NYC OpenData Street Centerline (2022); 3. NYC OpenData Sidewalk (2022).

Refine matching of buildings to streets sections[1] to ensure appropriate building-to-street section mapping; multiple iterations to troubleshoot treatment of corner buildings (i.e., reduce mapping to sections most proximate to corner).

Refine with common-sense stress testing of top-down archetypes given practical knowledge of city from urban planning perspective.

Categorize street sections into archetypes, which entails validating top-down approach with granular bottom-up analysis using land use and residential units data by building, matching buildings to street sections, calculating building type share for all street sections, and then categorizing street sections into archetypes.

Waste-to-volume conversion by street section

Convert DSNY residential tonnage data per sanitation section to granular per-street view by mapping of resident buildings and street sections.

Conduct analysis of DSNY Multi-Unit Building Survey (MUBS) data, triangulated with multiple sources of information (e.g., EPA, California, AIA Waste Calculator) to understand current-state waste to volume conversion.

Further refine key assumptions (e.g., which buildings have compactors, adjusting for potential false positives / negatives to identify which buildings might have compactors).

Utilize "maximum" versus "even" distribution of tonnage and volume for buildings facing multiple streets to assess maximum volume potentially required

Refining streetscape availability for streets and sidewalks

Take baseline data on street width and length from LION data on parking lanes, NYC OpenData Street Centerline and Sidewalk databases and refine

Overlay with data on hard constraints and soft constraints (e.g., fire hydrants, bus lanes, bus stops); overlays for driveways and other considerations where data is not available to be further investigated

Determine street availability factoring in constraints and assumptions, e.g., presence of one parking lane indicates maximum of one available street side for container placement

Define further constraints on street availability, e.g., snowplow requirements, clearance given container design & operations

Utilizing preliminary containerization details

Baseline potential containerization volume and dimensions to inform volumetric exercise using waste management expert interviews and market research (i.e., commercial product catalogs)

Assume 150% of waste generated would need to be contained in volumetric exercise to account for peak tonnage (e.g., during snow season, given other delays)

Fact Base to Assess Containerization Potential, *cont.*

	Key steps	Assumptions
Top-down approach	**1. Define "common-sense" archetypes for street sections** informed by practical residence stratification (e.g., detached 1-2 family, multi-family 50-150 units, high-rise buildings with 150+ units, hybrid) **2. Stress-test and refine list of archetypes through working sessions with core team** and experts in waste management	**Different geographic areas may have varying containerization needs** due to waste output and streetscape, which are proxied by residence type
Validate with granular bottom-up analysis (i.e., at street section level) to stress test and refine top-down approach	**3. Identify residence type for each building in NYC** using number of units and land use type in MapPLUTO (2022) data, and categorize into building types from top-down approach (e.g., detached 1-2 household, multi-family 50-150 units, high-rise buildings with 150+ units)	**Excluded following building types as not in scope**: 100% commercial, institutional buildings (e.g., NYCHA, DOE), buildings serviced by Ro-Ros and EZ-Packs; Averaged total units by number of buildings for aggregated "lots". "Lots" marked as having 0 units but had > 1 residential unit in PLUTO were assumed to have 1 building
	4. Match buildings to street section (i.e., every street any side of a building faces). Building matches are performed by applying a buffer area (1 sidewalk width around sidewalks, 4X sidewalk width + 0.5X street width, using specific respective street and sidewalk width values for each building) to match buildings to sidewalk sections (defined as contiguous sections of streets that are not intersected by any other major roads, streets, etc.), and then sidewalk sections to street sections[1]	**For buildings facing multiple streets: applied "maximum" distribution**– i.e., all units applied to each street face (e.g., a building facing three streets will be counted three total times) Excluded street sections <61 feet in length (e.g., short alleys) from the analysis
	5. Calculate share of residential units on a street section that fall into each building type (e.g., 50% of residential units on a street section are in detached 1-2 family buildings while 50% are in high rises)	Divided sum of units in each building type by the total number of units on that street section
	6. Categorize street sections into archetypes based on thresholds: List of archetypes: At or near 100% detached 1-2 family homes At or near 100% 1-6 story row houses At or near 100% multi-story buildings with 10-50 units At or near 100% multi-story buildings with 50-150 units At or near 100% large high-rise residential buildings (150+ units) Hybrid – Mixed but at least one large high-rise (150+ units) Hybrid – Mixed across residence mixes without a high rise Edge cases, including campus-like development (e.g., Stuyvesant Town, Baychester)	"**At or near 100%" defined as any street section where 80-100% of the units** meet the primary residence mix criteria; 1-2 family homes defined as detached / semi-detached 1-2 family homes in proximity codes 1 and 2 MapPLUTO (2022) data; 1-6 story row-houses identified as attached 1-2 family buildings or multi-family buildings with <10 units; **High rises identified as buildings with 150+ units per rules** (effective April 1, 2022) requiring buildings with 150+ units to submit waste management plans[2]; Street sections with at least one high rise assigned to "Hybrid – Mixed but at least one large high-rise (150+ units)" when not already assigned to an "at or near 100%" archetype; Edge cases identified as street sections with large campus-like developments indicated by >8K units; **Street sections that do not fall into any of the other archetypes were assigned to "Hybrid – Mixed** across residence mixes without a high rise"

Weight-to-Volume Conversion

Adjusted conversion factor for compacted refuse accounts for potential false positives from proposed approach to determining if buildings have compactors, based on the preliminary findings from DSNY's Multi-Unit Building Study as of November 2022. [1]

Compacted[2]: $\left(\frac{234^{6}}{288}\right)\left(140^{4}\ \text{lbs/yd}^3\right) + \left(\frac{54^{7}}{288}\right)\left(81^{5}\ \text{lbs/yd}^3\right) =$ **129 lbs/yd³**

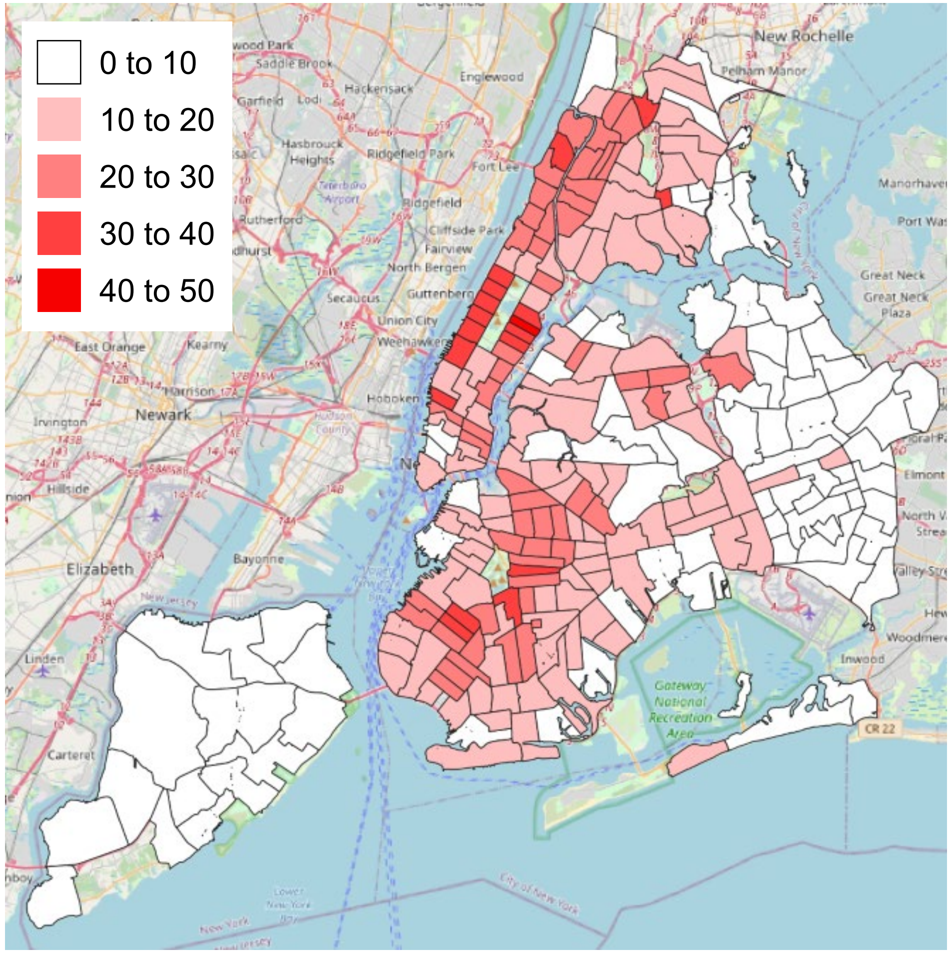
Uncompacted[2]: $\left(\frac{80^{8}}{620}\right)\left(140\ \text{lbs/yd}^3\right) + \left(\frac{540^{9}}{620}\right)\left(81\ \text{lbs/yd}^3\right) =$ 89 lbs/yd³) **(use 81 lbs/yd³)**

1. Incorporates compactor rule performance analysis (e.g., false positives) into weight-to-volume conversion factor calculation
2. Buildings that fit the proposed approach for determining if a building has compactors (built in 1968 or after with 4+ floors and 12+ units) are used as a proxy for determining weight-to-volume conversion for compacted refuse. Buildings that do not fit the proposed approach are used as a proxy for determining weight-to-volume conversion for uncompacted refuse
3. Based on MUBS data analysis and approach assessment, there are buildings that do not fit the proposed approach but still report having compactors. Given sample size considerations, use preliminary value for uncompacted refuse (i.e., lower conversion rates yield higher volume estimations)
4. Preliminary value for the compacted refuse weight-to-volume conversion as outlined in previously discussed step-by-step methodology (see previous pages)
5. Preliminary value for the uncompacted refuse weight-to-volume conversion as outlined in previously discussed step-by-step methodology (see previous pages)
6. The proportion of the 288 respondent MUBS buildings that are captured by the proposed approach that do report having compactors
7. The proportion of the 288 respondent MUBS buildings that are captured by the proposed approach that do not report having compactors
8. The proportion of the 620 respondent MUBS buildings that are not captured by the proposed approach that do report having compactors
9. The proportion of the 620 respondent MUBS buildings that are not captured by the proposed approach that do not report having compactors

Waste Output Analysis

Average daily volume per residential street section

Cubic Yards/day



Step-by-step method:

1. Monthly tonnage per sanitation section

Average monthly tonnage over the last 5 years for each sanitation section

2. Monthly tonnage per residential unit by section

For each section, divide (1) by total number of residential units in that sanitation section

3. Monthly tonnage per building

For each section, multiply (2) by the number of residential units in each building for all buildings in the sanitation section

4. Building tonnage by stream

For each building, divide tonnage into streams by composition (e.g., from WCS, OMD)

5. Estimated volume by applying weight-to-volume conversion factors for different streams by building type

Weight-to-volume factors from various sources (e.g., MUBS, EPA)

6. Building waste output by stream

For each stream per building, multiply (4) and (5)

7. Building to street section matching

Apply a buffer to match buildings to sidewalks, and then sidewalks to street sections

8. Street section waste output volume by stream

For each street section, sum over (6) for all buildings on that street section and divide by 30 to reach a daily approximation

Refinement of Fact Base to Assess Containerization Potential

Mapping of all resident buildings to streets | **Waste-to-volume conversion by street section** | **Refining streetscape availability for streets and sidewalks** | **Utilizing preliminary containerization details** | **Providing further validation and refinement via site visits**

Convert DSNY tonnage data per sanitation section to granular per-street view by mapping of resident buildings and street sections

Conduct analysis of MUBS data, triangulated with multiple sources of information (e.g., EPA, California, AIA Waste Calculator) to understand current-state waste to volume conversion

Further refine key assumptions (e.g., which buildings have compactors/balers, adjusting for potential false positives / negatives to identify which buildings might have compactors)

Utilize "maximum" versus "even" distribution of tonnage and volume for buildings facing multiple streets to assess maximum volume potentially required, per DSNY guidance

Assign subsection with corresponding frequency to each pickup by waste type

Mark pickups without corresponding scheduled frequency as **unassigned**

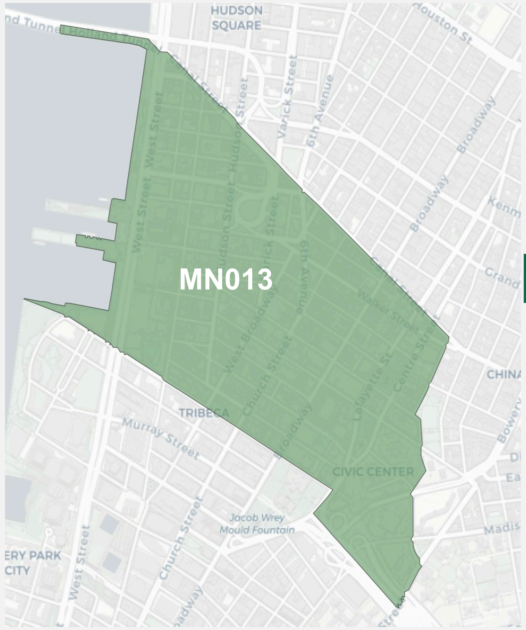
Aggregate assigned and unassigned pickups **by week and section/subsection starting from 2017**

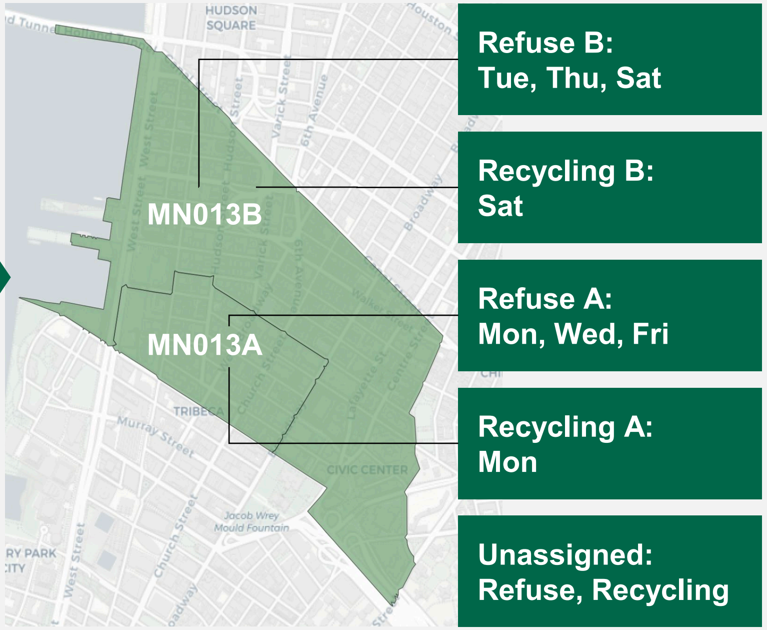
Distribute unassigned (~5% of total tonnage) pickups across subsections proportionally to number of residential units

Distribute average daily tonnage across buildings within subsection according proportionally to number of residential units

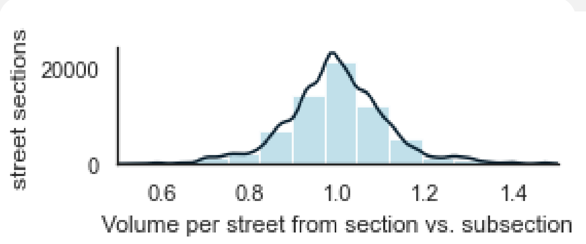
Map resident buildings to streets

Example:





Implications:



Deviations in shares of # of street sections by solvability are **within 0.1 p.p** in comparison with monthly/section level approach

Sources:, Google Maps, DSNY OMD Monthly Tonnage (2022), DSNY OMD Daily Collection data (2022), NYC OpenData Sidewalk (2022), NYC OpenData Street Centerline (2022), MapPLUTO (2022), NYC MUBS (2022), U.S. EPA Office of Resource Conversation and Recovery (2016), Facility-Based Characterization of Solid Waste in California (2018), Zero waste calculator, AIA New York Center for Architecture (2017), NYC OpenData – NYC Bus Lanes (2022), Baruch College – NYC Bus Stops (2020), NYC DOT Traffic Signs (2022), NYC OpenData – NYCDEP Citywide Hydrants (2022).

Assumptions Regarding Constraints for Container Placement on Street

	Factors	Approach
Total Possible Length	Street section	Total Possible Length
Constraints	Protected / bike lanes	Unless parking protected, eliminate side of street with protected bike lane
	Bus lanes	Eliminate side of street with curbside bus lane, unless parking remains
	Citi Bike Stations	Subtract Citi Bike Station from available street length
	Thoroughfares / parking exclusions[3]	For all parking signs on a particular street section side, cut street length by % of signs that are No Parking/Stopping/Standing Anytime
	Fire hydrants	Subtract 30 feet per hydrant from street length
	Private streets	Exclude private streets
	Bus stops / shelters	Subtract 60 feet per bus stop
	Curb / intersection radius	Subtract 10 feet from each side of street to allow for intersection visibility
	Driveways	To be considered as field research haircut
	Unprotected bike lanes Traffic volume Scaffolding Outdoor dining	Soft constraints that can be adjusted
Available Length	**Total Possible Length minus length occupied by obstacles / constraints** per street section	Available Length for a side of the street = Length – subtractions from hard constraints

International City Case Studies

Case Study: Amsterdam

City	Implications	Description
Amsterdam	**Container placement prioritized by stream**	**Approach to container placement:** For denser locations using underground containers, city prioritizes placing higher-use waste stream containers closer to residents (i.e., refuse within ~100-150 meters), over lesser-use waste stream containers (e.g., textiles within ~250 meters) For more residential areas, bins must be stored on resident's private property out of public sight until collection day
	Incentivizing resident behavior through design and placement	**Encouraging resident behavior:** City has explored improving the aesthetics of container areas (e.g., adding flower beds) and placing containers in areas that are visible to the pedestrians (i.e., increasing social pressure) to encourage residents to place bags inside of the containers. The city has implemented other programs such as "Adopt a Container" to increase accountability and a publicly available map to find the nearest waste container site
	Dynamic collecting pilot suspended for all public trash bins	**Approach to routing:** In 2014, the city added weighing mechanisms to collection trucks, installed 400 fill-level sensors in public trash bins to attempt to understand when underground containers were ready for collection, and experimented with dynamic routing. • The city still experienced overflowing containers and dynamic collection was ultimately suspended
	Balance between maintaining efficient fleet and overspecializing	**Implications on fleet**: City uses hoist truck with top-loader for underground containers, however given the high number of loose bags on the street, the city maintains rear-loading trucks which are used to manually collect bags before the hoist trucks conduct their routes. Neighborhoods may see double runs of the same route due to lack of flexible trucks (hoist and manual); potential overspecialization in hoist trucks
	Balance between maintaining efficient fleet and overspecializing	**Under and overground infrastructure:** City has access to and leverages a comprehensive database which includes all underground wires when determining locations for containers, created in collaboration across private Dutch engineering and construction companies.

Amsterdam publicly available map of all waste container sites

Case Study: Barcelona

City	Implications	Description
Barcelona	**Model design informed by neighborhood needs**	**Approach to model selection:** Models determined at the zone level (city has 4 zones); • City primarily uses stationary multi-use containers (~80% of city's waste) differentiated by stream, but leverages a variety of other containerization models (e.g., implemented a pneumatic system when it redeveloped a neighborhood for the 1992 Olympics; uses mobile containers moved at different times of day for areas with limited street/sidewalk space; manually collects bags in denser areas where trucks cannot fit)
	Proximity and choice to increase resident engagement	**Approach to container placement:** Prioritizes having recycling locations within ~100 meters of all residents to increase ease of disposal **Encouraging resident behavior:** Scheduling challenges remain as residents are supposed to take out trash at 8pm but often take out at other times
	Mismatch between disposal items and design may contribute to overflow	**Encouraging resident behavior:** Shape of bins may account for variation in size/design of recyclables – items may sit outside of the bin or be improperly disposed of as waste if they do not fit in bins
	Balance between maintaining efficient fleet and overspecializing	**Implications on fleet:** Operating the variety of containers in Barcelona requires a **heterogenous fleet** • Fleet includes trucks for mobile containers, small electric trucks for mountainous area of the city, and both hoist and side-load trucks to service stationary shared containers • Overflow challenges require the city to send multiple trucks on the same route (a secondary shift required to collect the trash left behind during the day)

Hoist truck

Case Study: Paris

City	Implications	Description
Paris (1/2)	**Small rolling bins and high collection frequency may introduce efficiency challenges where volume of waste is larger**	**Approach to model selection:** Uses primarily rolling containers; stationary for glass • Size of containers depends on whether it is a landed property or apartment building; building managers take bins to street • Rolling containers are color-coded: recycling (yellow lids) and general waste (blue); stationary shared containers are used for glass • Container size varies from 20 to 200 gallon bins (~1 cubic yard or less). Each building has one bin for waste and one for recycling; residents often complain that bins fill quickly **All apartment buildings provide containers for refuse; only 85% of buildings provide containers for recycling** • Residents without recycling containers in their building may use public recycling enclosures (e.g., Tri'lib) **High collection frequency:** Daily for waste (morning or night), and 2-3 days/week for recycling in most parts of the city. Parked cars can obstruct hauling of containers and Individual bin may not hold larger recyclables, resulting in overflow
	Potential trade-off between cleanliness of public space and efficiency	**Approach to routing:** According to experts, routing is not optimized for full-container retrieval as city planners prioritize cleanliness of public space over efficiency. Per expert, each container can be up to ~25% empty when collected

Overflowing individual bin

Case Study: Paris, *cont.*

	Implications	
Paris (2/2)	**More limited roll-outs to stress test operationalization have been valuable mechanism for testing containerization before scale**	**Approach to container placement:** In 2016, introduced Trilib as new recycling container to address lack of storage space within buildings and low recycling rates • Four to six modules and up to five streams: metal and plastic packaging, paper and small cardboard, glass, textiles and large cardboard; each are color-coded with their own type of opening • Foot pedal-operated openings on the sidewalk and street-facing doors for sanitation crew to remove wheeled shared containers • After rolled out, the city saw challenges of overflowing due to improper items in large cardboard openings and noise due to lack of insulation for glass – repaired by narrowing slot for cardboard and adding noise insulation in glass containers **After the pilot's success for a few years, procured 1,000 stations** with greater capacity to reduce collection frequency
	Standardized design of fleet may assist in regular upkeep/ modernization	**Implications for fleet:** Entire fleet is comprised of rear-load trucks, which are often modern (renewed every ~5 years) • Streamlined fleet may be possible due reliance on rolling bins • Mechanized nature of trucks requires truck drivers to operate the vehicle and loaders to manually place bins in rear of truck • Some buildings pay for the operators to collect containers inside the building as an added service; in standard service, building managers roll bins to the curb where operators collect

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