

**URBAN
GREEN**



**PREPARED
FOR NYSEERDA**

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PROJECT PARTNER



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Associates, Inc.

SPENDING THROUGH THE ROOF

Urban Green Council

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A nonprofit organization established in 2002, Urban Green’s in-house experts and a dedicated network of volunteers are helping to transform the built environment in New York City with models that can be replicated in urban centers nationwide.

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INTRODUCTION

Winter, New York City. A tall apartment building on a cold February day. A shrill whistle emerges from the door keeping you from the lobby. A tug on the door handle does nothing—it's like it's glued shut. Mustering extra strength, you manage to pull the door open, only to be blasted by a strong gust of wind, practically knocking you off your feet. For this, you pay the highest rent in the country?

Tall buildings act like chimneys in cold weather. Heated air rises out the top through cracks and gaps in the roof. This draws frigid air in through the bottom, making the boiler run overtime to keep the building warm.¹ In this report, we'll focus on one of the biggest sources of roof air leakage: the open vents at the top of elevator shafts in tall residential buildings. The leaks are large, but relatively easy to fix.

Apartment building owners spend an average of \$3,400 each year to heat air that escapes through the roof. For taller buildings, the cost can be well over \$20,000 each year.

For years, elevator shaft vents could only be partially covered to limit heat loss. But a 2014 change to the [New York City Building Code](#) allows new solutions.²

Fixing the leaks is relatively inexpensive—about \$500 to \$15,000 per building. But the citywide impact is large. If simple repairs were performed on 4,000 tall apartment buildings in NYC, it would cut greenhouse gas emissions by 30,000 metric tons and save over \$11 million every year.

In this report, we'll explain how these leaks translate into energy losses for your building and others citywide. Then we'll discuss solutions, and explain how we came to our conclusions. Finally, a [How-To Guide](#) provides step-by-step instructions on how to eliminate or lessen these leaks and save money.³

With simple repairs, NYC apartment buildings could save \$110 million in 10 years.

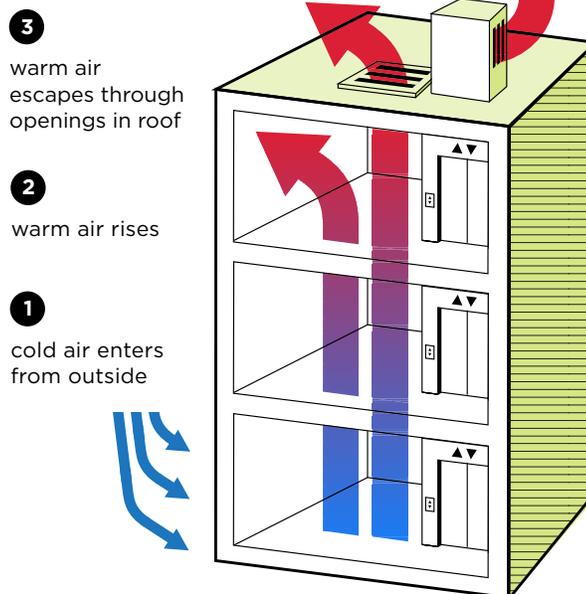
AN OLD PROBLEM

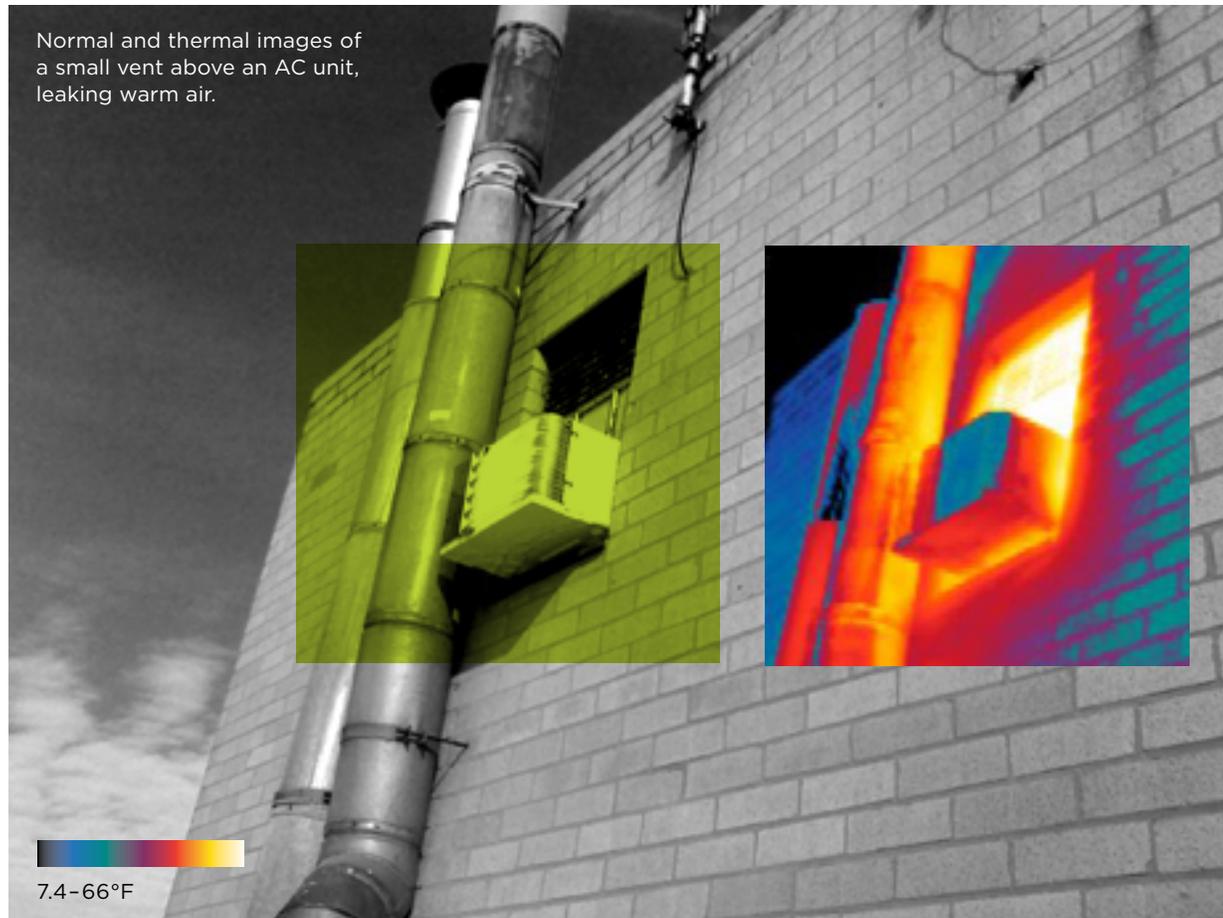
New York City Fire Department and New York State regulations require openings at the top of elevator shafts and stairwells in many tall multifamily buildings and hotels. Originally meant to improve fire safety by drawing smoke out of the building, changes in building construction and firefighting practice mean these vents are needlessly open all the time. Today, they mostly serve as big unwanted holes, passing heated air out the top all winter (Figure 1). When you open the front door to your building, the cold blast you feel is air rushing in to replace the air leaking out the top and chilling the entire lobby.

Buildings with open elevator vents lose heated air at a staggering rate in the winter. Elevator vents alone will leak about a living room's worth of warm air every minute.⁴

This leakage has both financial and environmental costs. All the air that escapes through open vents is replaced with cold air from outside, which then needs to be warmed by the building's heating system. That means that 4-16% of heating fuel is being used to heat the outdoors,⁵ most of which can be saved by fixing these holes.

Figure 1: In winter, warm air escaping through openings in the roof mean that cold air is drawn into the bottom of the building.





A 15-story multifamily building in a dense city block loses \$3,000 through the roof each heating season.⁶ Where buildings are farther apart, greater exposure to wind increases the airflow, more than doubling the cost to \$6,500.

The taller the building, the more air is lost through the same size hole. A close-packed 30-story building wastes \$6,000 each winter. And in a less dense area, that bill increases to \$13,000. The [How-To Guide](#) on page 10 shows how to estimate the savings potential from closing these vents.



Figure 2: Building height and density comparison

A CITYWIDE ISSUE

What are the citywide effects of this wasted energy? There are approximately 4,000 multifamily buildings in NYC that are at least 10 stories tall—the threshold where heat loss through vents really starts to make an impact on energy bills. Assuming that 80% of these have open vents, the amount of heated air wasted each year could fill 29,000 Empire State Buildings.⁷



When thousands of lobbies lose their warm air, thousands of boilers must kick on and heat the cold air that's come in to replace it—with a cumulative energy impact predicted at over 460 billion BTUs annually, equivalent to 80,000 barrels of oil. This means that every year, building owners and tenants are paying over \$11 million in unnecessary heating costs citywide.⁸

This energy expense has an environmental cost as well. About 30,000 metric tons

of carbon dioxide equivalent (CO₂e) are needlessly released into the atmosphere each year from this wasted heat. If these vents are left open until 2050, over 1 million metric tons of CO₂e will be emitted. This is equivalent to the annual energy use of over 90,000 homes. Capturing “low-hanging fruit” like these simple fixes is necessary to reach citywide carbon reduction goals, as described in [One City: Built to Last](#), NYC's plan to reduce greenhouse gas emissions 80% by 2050⁹ and in [90 by 50](#), Urban Green's comparable study.¹⁰

SOLUTION: PLUG THE HOLES

Previous versions of the NYC Building Code allowed for only the partial closure of elevator shaft vents, but the 2014 update allows new solutions. Stairwell vents are governed by the New York State Multiple Dwelling Law, which has not changed since 1929, and so far there is no legal way to close or modify them. Therefore, our recommendations deal only with elevator shaft vents.

These vents come in a range of sizes and shapes, from simple openings to more complicated systems. They can be found in the walls or ceiling of elevator rooms and are typically at least three square feet in area. Building maintenance staff can assess the vents, estimate the energy losses and savings, and perform the retrofit either in-house or with the help of a consultant.

There are two main options for retrofits:

1. Cover two-thirds of the vent with annealed glass, and leave the rest open.
2. Install a motorized set of louvers that will remain completely closed until there's a fire, when the alarm system or a smoke detector will open them.

The first option is best for smaller, simpler buildings, and can be installed inexpensively in-house by building maintenance staff. (Building owners opting for this method may wish to engage a consultant for advice on design and code compliance.) The cost ranges from \$500 to \$2,000 per vent, depending on the in-house capabilities of building staff, with a simple payback period of less than one year, depending on the details of installation.

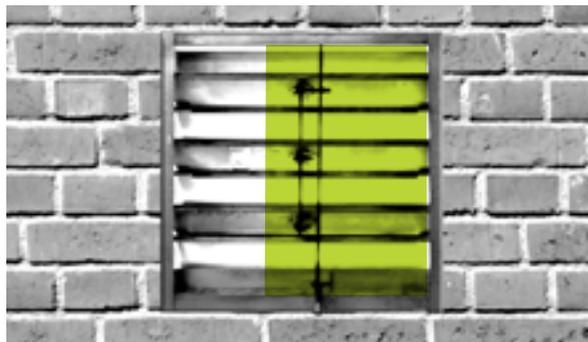


Figure 3: Vent with glass covering 2/3 of vent area

The second option, installing motorized louvers, is now a possible retrofit solution thanks to a recent change to the NYC building code. The total vent area can be covered as long as the louvers will open upon detection of smoke, loss of power, or manual override. This requires electricity and access to the fire system, so the project will need to be overseen by a qualified engineer or contractor to ensure that all code requirements are met.

This solution is best for larger, more sophisticated buildings. The cost can range

between \$5,000-\$15,000 per vent, depending on access to the various systems and other site-specific concerns. Although it's a pricier solution, the payback period is similarly short (one to five years depending on the details of the installation) and will save significant money in the long term. One example of this is shown in Figure 4.

In addition to the financial cost and savings, owners should consider the value of the improved comfort for building occupants and increased safety and security with lobby doors that open and close easily.



Figure 4: A motorized, fully closing vent

NEXT STEPS

Sealing open elevator shaft vents is a simple and low-cost solution that immediately saves money and energy. Depending on size, buildings can save several thousand dollars annually from a capital outlay that will be repaid in one to five years.

But there's no reason to stop there. An energy audit can locate other air leakage issues around windows, doors, and mechanical equipment. These leaks can easily be sealed to save even more money and energy. Other added benefits include more uniform indoor temperatures and increased building resiliency during extreme weather. And the audit can find many other areas where fuel and electricity use can be lowered cost-effectively.

More than just a technical issue, the next step is to build consensus with building stakeholders—including residents, owners, and managers—for ongoing energy efficiency improvements such as air sealing, insulation, and mechanical system upgrades. Here are some tips:

- Focus on benefits: sealed vents not only reduce energy bills, but make lobbies more comfortable and front doors easier to open when it's cold.
- For co-ops and condos, research the building's bylaws and speak with individual board members before bringing proposals to the board. This will show that you understand the approval process.
- Emphasize the shared goals of lowered maintenance expenses, safety, and resiliency.

After improvements have been made, the key to maintaining these energy savings is a well-

trained staff. Training in maintenance and operations can reduce energy use by 5–20%.¹¹ Programs like those at the Building Performance Institute¹² (for residential buildings), Building Operator Certification¹³ (for commercial buildings), and Urban Green Council's GPRO¹⁴ can provide the necessary training for energy-efficient operations.

Here's what a few resident managers in New York City say about vents:

“I was amazed at the amount of air that was coming out of those vents ... air that we just paid to heat!”

“Closing down the large, previously open vent at the top of my building basically stopped my elevators from whistling in the winter. It had a huge impact.”

“We want to take care of these vents—this is the real low-hanging fruit right here.”

HOW-TO GUIDE FOR FIXING AIR LEAKS

STEP 1: ASSESSING YOUR BUILDING

To assess your building’s potential energy savings using the worksheet on p. 14, you need to provide information on five basic characteristics:

1. Building Height

Tall buildings lose more heat. You’ll enter the height of your building in number of floors. The guide that follows assumes 10 feet per floor, an average height for tall buildings.

2. Wind Exposure

The more exposed a building is to the wind, the greater the loss of warm air through the roof. Select which **terrain class** best fits your building: 1—large city center with nearby buildings 80 feet tall or higher; 2—urban or suburban areas with nearby buildings 20 to 80 feet high; 3—suburban areas with nearby buildings below 20 feet in height.

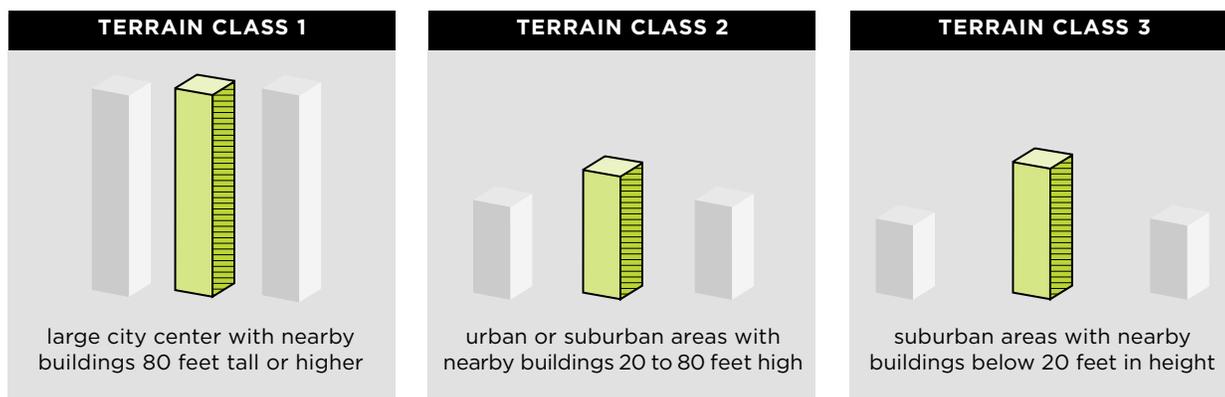


Figure 5: Terrain classes are based on a building’s potential for wind exposure.¹⁵

3. Vent Size

The minimum vent size is determined by Section 3004 of the 2014 NYC Building Code, which requires the area of the vents to be at least 3.5% of the area of the hoistway or at least three square feet for each elevator car, whichever is greater.

However, the vents may be larger or smaller than required due to design or construction errors. You'll need to determine the building's "vent free area" (through which air can flow), and should measure each individual vent to estimate this number.

First, calculate the gross area of the vent. If the vent is rectangular, multiply the width by the height. If the vent is a more complicated shape, a more complicated formula may be required. Measure to the outside edges of the vent assembly, which will normally be the inner edges of the building wall.

Using Figure 6, you can then calculate the vent free area, or the percentage that is open for airflow based on the spacing and angle of any louvers or screens placed over the opening. It will always be less than the gross vent area. Choose the one that looks the most like each vent you are analyzing, and multiply that fraction by the gross area to determine the vent free area. If you think your vent is between two of the vents in the figure, use an intermediate percentage, such as 62% or 37%.

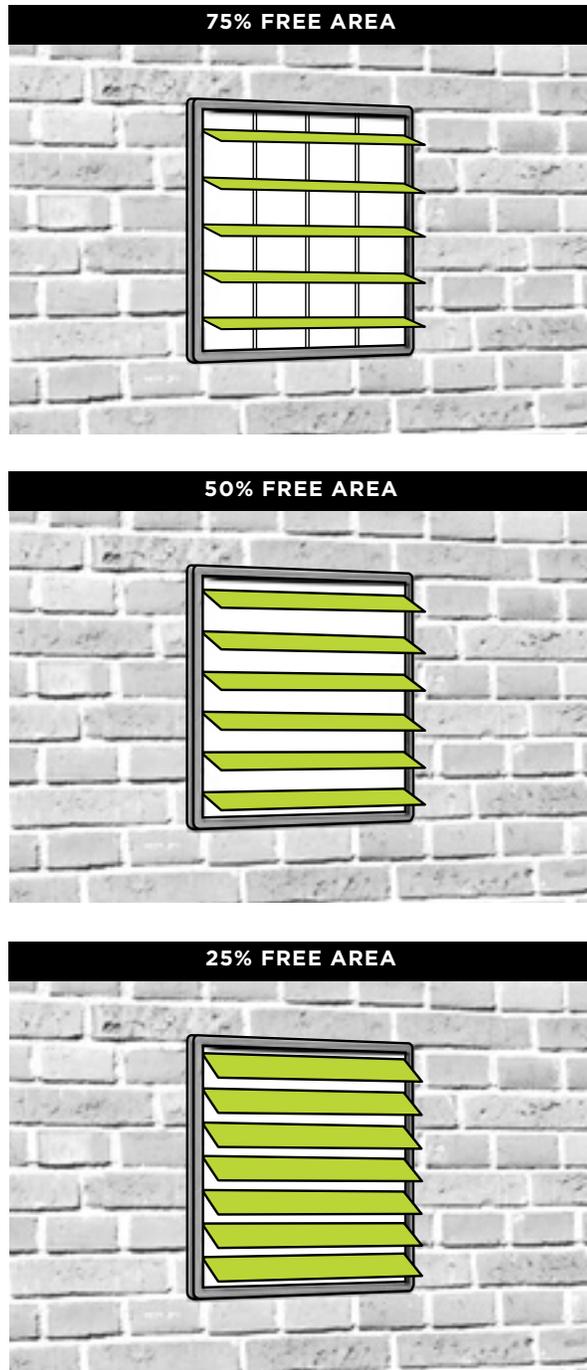


Figure 6: Vent free area estimation: Vents showing a range of percent free areas, based on how the louvers are spaced and angled. On the left, the louver is nearly wide open but with some obstructions. In the center, the louvers are more angled. At the right, the louvers are more tightly spaced and nearly closed.

4. Air Leakage

A building's envelope is a good indicator of overall leakage throughout the building, with “tight” buildings losing more air through open rooftop vents than a “typical” building. An example of a tight envelope is a curtain wall building where there are no substantial penetrations on the majority of exterior walls. “Typical” buildings will have walls penetrated by items such as PTAC openings, AC sleeves, or distributed ventilation openings. Most multifamily buildings fall into the “typical” category. You can use the age of the building as a proxy, with buildings constructed before the year 2000 as “typical” and buildings constructed in 2000 or later as “tight.”

5. Outdoor Temperature

Warm air travels from areas of higher temperature to lower temperature, so buildings with colder outdoor temperatures will experience greater heat loss. The number of Heating Degree Days (HDD) for the heating season is a measure of the average outdoor temperature at that location. The calculations below are based on 4,777 HDD for NYC. If the building is outside of NYC, multiply energy savings by the ratio of HDD in your area to the HDD in NYC.

Note: Your calculated savings estimates are based on a sample set of New York City buildings that provide a good representation of building types. However, because all buildings have unique characteristics beyond our criteria, as well as differing levels of quality in executing the work, your energy savings and payback period may be higher or lower than our estimates.

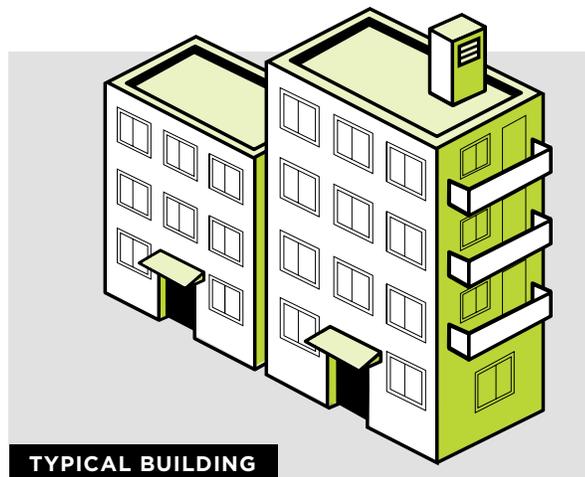
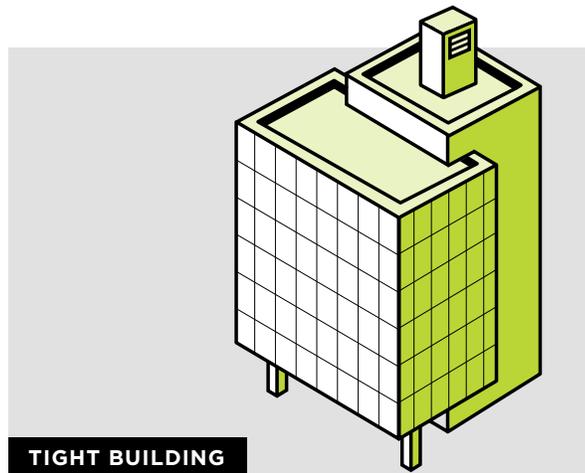


Figure 7: Example of a “tight” and a “typical” building

STEP 2: ESTIMATING YOUR SAVINGS

1. Enter the number of floors from Step 1, Page 11	<input type="text"/>	BOX 1
2. Enter the wind exposure class from Step 2, page 11	<input type="text"/>	BOX 2
3. Multiply your vent size (in square feet) by the vent free Area from Step 3, page 12. If there is more than one vent, multiply this by the total number of vents	<input type="text"/>	BOX 3
4. Enter whether your building is “Tight” or “Typical” from Step 4, page 13	<input type="text"/>	BOX 4
5. Enter the number of Heating Degree Days in your location from Step 5, page 13	<input type="text"/>	BOX 5
6. Enter your Energy Savings Factor using Table 1, page 15, based upon the responses in Boxes 2 and 4	<input type="text"/>	BOX 6
7. Multiply Boxes 1, 3, and 6 to find your estimated energy savings	<input type="text"/>	ENERGY SAVINGS (MILLION BTU)
8. Multiply the Energy Savings by the building fuel cost from column 3 in Table 3, page 16 (if you know the rate) or Table 4 (if you are unsure)	<input type="text"/>	ESTIMATED COST SAVINGS

1. Estimating the Impact

We've provided two ways to estimate the impact of closing vents in your building. The first will help you estimate the potential energy savings in millions of British Thermal Units, or MMBtu. The second will help you estimate the annual air loss through open vents (in cubic feet per minute, or CFM). Use the estimations

above to find the appropriate impact number (Energy Savings Factor or Airflow Factor) for your building from the following tables, then insert it into the formula that follows each table. Each situation is unique, so your energy savings and payback period may be higher or lower than calculated here.

Table 1: Estimating the Energy Savings from Closing Open Vents

Energy Savings Factor ¹⁶		Terrain Class		
		1 - City Center	2 - Urban	3 - Suburban
Wall Construction	Typical	1.7	3.8	4.8
	Tight (Curtain Wall)	2.5	5.4*	6.9*

*These values are based on engineering estimates; all others on empirical data.

Multiply the Energy Savings Factor by the number of floors in the building and a vent's free area in square feet to arrive at the estimated annual heating energy savings for that vent, using this equation. If you have more than one vent in your building, you can add all the vent areas together to calculate total energy savings for the combined vents.

$$\begin{aligned} &\text{Energy Savings} \\ &\text{(MMBtu/year)} \\ &= \text{Number of Floors} \\ &\times \text{Vent Free Area (sqft)} \\ &\times \text{Energy Savings Factor} \end{aligned}$$

Table 2: Estimating the Airflow Through an Open Vent

Airflow Factor ¹⁷		Terrain Class		
		1 - City Center	2 - Urban	3 - Suburban
Wall Construction	Typical	18	34	39
	Tight	20	39*	45*

*These values are based on engineering estimates; all others on empirical data.

Multiply the Airflow Factor by the number of floors in the building and a vent's free area to arrive at the estimated annual air losses for that vent, using the following equation. If you have more than one vent in your building, you can add all the vent areas together to calculate total air loss for the combined vents.

$$\begin{aligned} &\text{Air Lost (CFM)} \\ &= \text{Number of Floors} \\ &\times \text{Vent Free Area (sqft)} \\ &\times \text{Airflow Factor} \end{aligned}$$

Important Considerations for Energy Savings Estimations:

- If the vent will not be closed entirely (using annealed glass to cover 2/3 of the area) energy savings will be reduced. Multiply the energy savings shown by the calculation on page 14, line 7 by 60% to estimate your result.
- If estimating for a building that is not located in NYC, multiply the energy savings by the ratio of Heating Degree Days for the building climate over the NYC Heating Degree Days. (This analysis used 4,777 Heating Degree Days for NYC from Typical Meteorological Year data, or TMY3.)
- The amount of air saved when vents are sealed is not equivalent to the amount of airflow through a vent when it was open. Closing the vent increases the pressure in

that section of the building, which forces more airflow through the remaining building penetrations. Our study found that for the building population surveyed, the average reduction of infiltration is around 70% of the pre-closure airflow. This effect has already been included in the values of the Energy Savings Factor. If you'd like to estimate the reduction in the amount of cold air flowing into the building, multiply the "Air Losses" calculated above by 70%.

2. Estimating the Cost Savings

Knowing the heating energy to be saved, you can find the financial savings from the following formula. Here the Energy Savings are in MMBtu from the formula just above. If you know what you paid for fuel, you can use Table 3 to convert to dollars per MMBtu.

Table 3: Fuel cost conversion factors

Fuel	Cost in	Multiply by	To get
#2 Oil	\$/gallon	7.246 gallon/MMBtu	\$/MMBtu
Gas	\$/therm	10 therm/MMBtu	\$/MMBtu
Electricity	\$/kWh	293 kWh/MMBtu	\$/MMBtu
Steam	\$/pound	1031 lb/MMBtu	\$/MMBtu

Table 4: Average fuel costs and environmental impact in NYC

Heating Types in NYC	% of NYC Apts.	Cost / MMBtu	kg CO2e / MMBtu
#2 Oil	45%	\$27.05	74.76
Gas	44%	\$12.50	53.15
Electricity	5%	\$56.69	89.76
Steam	6%	\$29.31	57.52

Source: 2011 New York City Housing and Vacancy Survey¹⁸ and 2014 Inventory of New York City Greenhouse Gas Emissions¹⁹

STEP 3: IMPLEMENTING SOLUTIONS

There are two ways to reduce air loss through elevator shafts to achieve savings.

Option 1: Cover 2/3 of the total vent area with annealed glass

1. The annealed glass used to cover 2/3 of the total vent area must be no more than 1/8" thick.
2. The remaining 1/3 of total vent area must remain open.
3. The glass can be installed by in-house staff or a third party.
4. It may be useful to engage a consultant for code compliance and design.
5. Best method for smaller, simpler buildings.
6. Cost: about \$500 to \$2,000 per building.

Option 2: Install a mechanical damper to fully close the vent opening

1. The work should be overseen by a qualified engineer, who must:
 - a. Ensure that all applicable building codes are being met. The project will need to be filed with the Department of Buildings.

- b. Develop damper specifications. Dampers should be rated Class III or Class IV to minimize infiltration (Class I and II dampers are not robust enough to appropriately withstand stack pressures at the top of a building).
 - c. Bid out the work and select a contractor (unless this is done by the building owner or manager directly).
2. This option is now permitted under the 2014 NYC Building Code (Section 3004), which allows complete closure of the vents with motorized louvers, as long as the louvers will open upon detection of smoke, loss of power, or manual override. Installation requires electrical power and access to a fire panel. This access may require substantial wiring.
3. Best method for larger buildings with more resources.
4. Cost: about \$5,000-\$15,000 per building, depending upon:
 - a. Access to electricity
 - b. Power and smoke alarms that must be connected to the new damper
 - c. Existing dampers that can be re-programmed/re-configured

Alternate Venting Strategies

There are other code-compliant methods of smoke control (in line with NYC Building Code Sections 3004.5.2 and 3004.5.3). These other options include mechanical ventilation or air pressurization of the hoistway enclosure, but the costs far outweigh any available

energy savings unless other building issues are addressed simultaneously. They might be pursued if a building has known pressurization issues or other site-specific attributes. Consultation with an experienced engineering firm is necessary.

STEP 4: FIXING OTHER AIR LEAKS

While closing elevator vents, take a look at other common rooftop air leaks. Find the biggest holes and seal them first. Sometimes these will be additional smoke or ventilation routes included at a time when energy was cheap and little thought was given to efficiency. Leaks can also occur around ventilation stacks, rooftop doors and hatchways, and plumbing stack vents.

Below the roof, many other air leaks can contribute to the stack effect. The most ordinary are in window frames, or even windows left open because of local overheating. Weather-stripping the hallway doors of apartments can minimize the impact of these leaks on the building as a whole. This has the added advantage of isolating the odors of cooking and smoking within a particular apartment, and is easily done by in-house staff.

When windows are replaced, it's best to replace the entire window, frame and all. Choose an ENERGY STAR high-performance window with an overall U-value of 0.35 or lower.²⁰ Fiberglass-framed windows meet the same fire code and strength requirements for multifamily buildings as standard aluminum-framed windows, and provide far better energy performance.

Internal doors, like those at the bottom of stairwells, are sometimes propped open, encouraging stack effect airflow and violating

fire code requirements. This practice should be stopped. Other internal doors, like those leading to lobbies with elevators, should also be kept closed whenever possible.

Buildings equipped with exhaust fans for bathrooms and kitchens should be checked regularly to ensure the fans and ducts are balanced. This way, air is removed equally from all floors and from each vented room on a floor and a floor, and the fans and ducts operate correctly in both winter and summer. A competent contractor must first ensure duct integrity and existing system operation. Many buildings have large gaps in ventilation ducts that are not easily visible during inspection but leak large amounts of air and prevent correct system operation. Remote viewers and pressure tests will find these leaks. A good next step is to install an intelligent fan system that will sense and maintain appropriate pressure in the return ducts. This work requires a specialist, but the cost will be repaid in a few years from savings in the heating bill.

APPENDIX 1: RESEARCH METHODOLOGY

This is a brief summary of the technical study performed by Steven Winter Associates.

Fifteen buildings were investigated, ranging from six to 50 stories in height. The flow of air across vents was measured in elevator shafts and stairwells, gathering data over several weeks between December 2013 and April 2014 in two-week intervals. This heating season in New York City totaled approximately 5,100 heating degree days, compared to 4,580 averaged for the previous 10 years, indicating that the winter was colder than average.

The following calculations used 4,777 HDD from Typical Meteorological Year (TMY3) data.

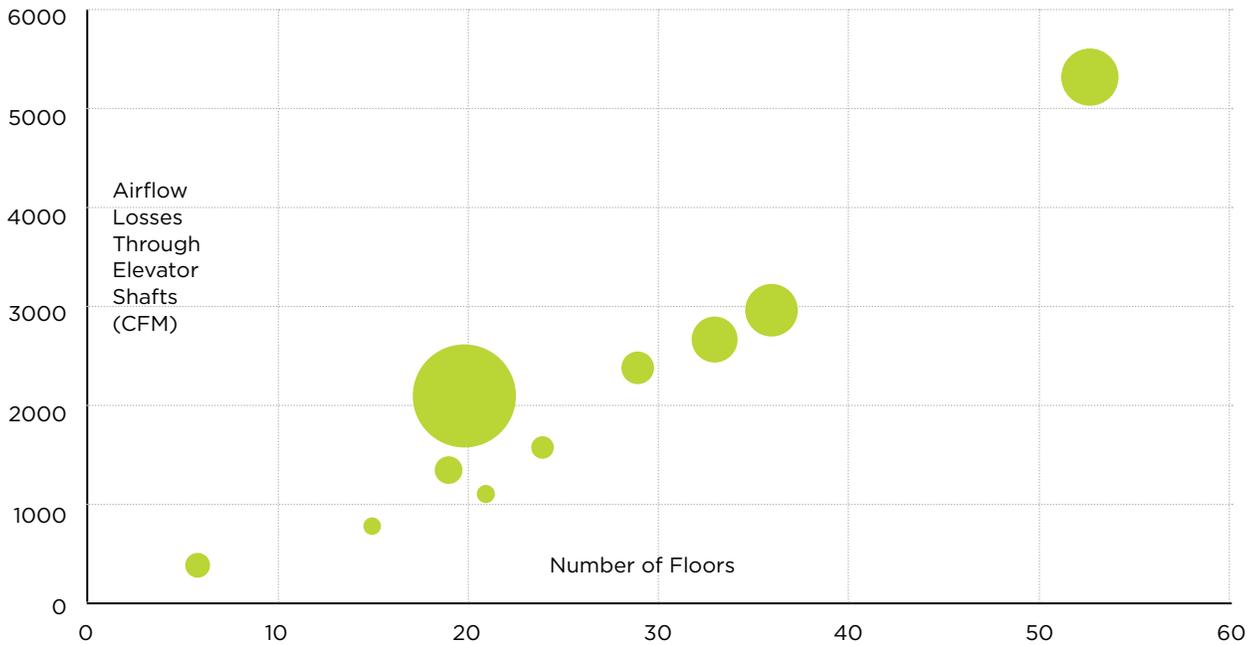
Results

Of the 15 buildings sampled, five had unusable data and were not included in further analysis. The remaining 10 buildings make up the sample population:

Table A1-1: Characteristics of Studied Buildings

Building	Building Height (floors)	Vent Free Area (sqft)	Envelope (typical, tight)	Terrain Class (1-3)	Season Energy Flow (MMBtu)
B1	20	8.3	Typical	1	332
B2	21	2.9	Typical	2	149
B3	29	2.7	Typical	2	399
B4	53	4.5	Typical	1	970
B5	6	1.9	Typical	2	62
B6	33	3.8	Tight	1	465
B7	36	4.3	Tight	1	521
B8	15	1.3	Typical	2	100
B9	19	2.3	Typical	2	227
B10	24	1.7	Typical	3	277

Figure A1-2: Vent airflow versus building height and vent free area



Note: Size of data point is proportional to the vent free area of the elevator vents.

All the air that leaves the building through the vent opening must be replaced with outside air, which needs to be conditioned by the building’s HVAC system. A correlation was derived between the calculated seasonal energy impact of the vents and several characteristics of the buildings to create a

normalized metric for energy impact. This metric can be used to quickly assess savings potential in closing up the vents on any building, and is expressed in the parameters Energy Savings Factor and Airflow Factor used in the How-To Guide.

APPENDIX 2: CITYWIDE IMPACT ESTIMATES

We also estimated the savings possible in New York City if the measures proposed here were carried out in all the buildings with open vents.

The NYC Department of City Planning's Primary Land Use Tax Lot Output (PLUTO) database version 14v2 was used to find every building in NYC with a height of 10 floors or more. Each tax lot has a single entry in the database, with cumulative information about all buildings on that lot, and detailed information about the "primary building" on the lot. Fields for building frontage, depth, and number of floors were used to approximate the floor area for the primary building. A rectangular floor shape was assumed for simplicity, although many multifamily buildings will have more complex shapes to ensure that every unit has access to a window.

The total floor area on the lot and the approximate floor area of the primary building were used to determine the number of "representative" buildings on the lot that most closely matched the known dimensions of the primary building. This provided a corrected number of buildings used in further calculations about energy savings.

The age of the building was used as a proxy for wall construction. Buildings constructed prior to 2000 were assumed to have "typical" walls, while buildings constructed in 2000 or later were assumed to have "tight" walls.

Additionally, if a building was located Manhattan, Terrain Class 1 was used, as it was more likely to be surrounded by many tall buildings. Terrain Class 2 was used for a building located in outer boroughs, as it is more likely to be surrounded by smaller buildings.

Using an average vent free area of three square feet,²¹ the energy impact was estimated for each building, and is shown in Table A3-1. The energy costs were calculated assuming a boiler efficiency of 83%, and the greenhouse gas (GHG) emissions²² were developed using coefficients from the New York City Inventory of GHG Emissions, presented in Table 4.

Table A3-1: Impacts for Individual Representative Buildings

Number of Floors	Borough	Wall Construction	Energy Impact (MMBTU)	Energy Cost (MMBTU)	Airflow Losses (CFM)	GHG Emissions (kg CO2e)
10	Manhattan	Typical	60	\$1,400	500	4,000
	Manhattan	Tight	90	\$2,000	600	5,900
	Other Boroughs	Typical	140	\$3,100	1,000	8,900
	Other Boroughs	Tight	200	\$4,300	1,200	12,700
20	Manhattan	Typical	120	\$2,700	1,100	8,000
	Manhattan	Tight	180	\$4,000	1,200	11,700
	Other Boroughs	Typical	270	\$6,100	2,000	17,800
	Other Boroughs	Tight	390	\$8,700	2,300	25,400
30	Manhattan	Typical	180	\$4,100	1,600	12,000
	Manhattan	Tight	270	\$6,000	1,800	17,600
	Other Boroughs	Typical	410	\$9,200	3,000	26,800
	Other Boroughs	Tight	590	\$13,000	3,500	38,000
40	Manhattan	Typical	250	\$5,500	2,100	16,000
	Manhattan	Tight	360	\$8,000	2,400	23,500
	Other Boroughs	Typical	550	\$12,200	4,100	35,700
	Other Boroughs	Tight	780	\$17,400	4,700	50,700
50	Manhattan	Typical	310	\$6,800	2,600	20,000
	Manhattan	Tight	450	\$10,100	3,000	29,400
	Other Boroughs	Typical	690	\$15,300	5,100	44,600
	Other Boroughs	Tight	980	\$21,700	5,800	63,400
60	Manhattan	Typical	370	\$8,200	3,200	24,000
	Manhattan	Tight	540	\$12,100	3,600	35,200
	Other Boroughs	Typical	820	\$18,300	6,100	53,500
	Other Boroughs	Tight	1,170	\$26,100	7,000	76,100

Finally, the per-building energy use, costs, and emissions for each building type and borough were combined with the PLUTO data and summed to give citywide totals for buildings of different heights. Although every building examined in this study had open vents, the totals were reduced by a more conservative assumption that only 80% of the buildings would have open vents amenable to improvement. The results are displayed

in Table A3-2, and show that closing these vents would reduce GHG emissions from large residential buildings in New York City between 0.5 and 1.0 percent.

Table A3-2: Cumulative Citywide Impacts

Number of Floors	Number of Buildings	Cumulative Energy Savings (MMBtu)	Cost Savings	Avoided Airflow Losses (CFM)	GHG Emissions Reduction (metric tons CO ₂ e)
>=10 and <20	2,903	319,200	\$7,767,000	2,446,000	20,700
>=20 and <30	688	118,200	\$2,876,000	918,000	7,700
>=30 and <40	304	70,300	\$1,998,000	535,000	4,600
>=40 and <50	104	37,200	\$843,000	273,000	2,400
>=50 and <60	33	15,100	\$344,000	108,000	1,000
>=60	13	11,500	\$274,000	76,000	700
Total	4,045	571,500	\$14,102,000	4,356,000	36,100
Total if vents are improved in 80% of buildings	3,236	457,200	\$11,282,000	3,485,000	29,700

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ENDNOTES

1. This is also known as the “stack effect”.
2. There are similar vents at the top of stairwells, but New York State law still prohibits their closure.
3. Our entire discussion is driven by research and analysis performed by engineers at [Steven Winter Associates](#). Their technical report is available for those who would like to dive deeper into the engineering details.
4. Air leaks from an average building at over 1,000 cubic feet per minute. The size of a living room is assumed to be 10 feet by 15 feet by 8 feet.
5. Estimated from buildings in this study where detailed utility data was available.
6. Assuming 83% boiler efficiency.
7. The Empire State Building has a volume of 37 million cubic feet:
http://www.esbnyc.com/sites/default/files/esb_fact_sheet_4_9_14_4.pdf
8. Using fuel costs from the 2011 NYC Housing and Vacancy Study, building data from PLUTO, an assumed heating system efficiency of 83%, and three square feet of open vent area per building. See Appendix 2.
9. One City: Built to Last (Transforming New York City’s Buildings for a Low-Carbon Future)
<http://www.nyc.gov/html/builttolast/pages/plan/plan.shtml>
10. Urban Green Council, “90 by 50: NYC Can Reduce Its Carbon Footprint 90% by 2050,”
<http://urbangreencouncil.org/content/projects/90-50>.
11. Measurement & Verification of the Green Supers Program, [Steven Winter Associates](#) and [32BJ](#)
<http://training.32bjfunds.com/en-us/green/greensupersforum.aspx>
12. [Building Performance Institute](#) develops standards for energy efficiency retrofit work using a consensus-based process built on building science <http://www.bpi.org/>
13. [Building Operator Certification](#) is a nationally recognized, competency-based training and certification program for building operators <http://www.theboc.info/>
14. [GPRO: Green Professional Building Skills Training](#) is a series of courses and certificate exams that teach the people who build, renovate, and maintain buildings the principles of sustainability combined with trade-specific green construction knowledge <http://gpro.org/>

15. American Society of Heating, Refrigerating and Air-Conditioning Engineers (2013). 2013 ASHRAE Handbook: Fundamentals. Atlanta, GA: American Society of Heating, Refrigeration and Air-Conditioning Engineers, Section 24.3, Table 1
16. The Energy Savings Factor shows MMBtu lost per floor per square foot of free vent area and number of floors in your buildings.
17. The Airflow Factor shows cubic feet per minute of air loss per floor per square foot of free vent area and number of floors in your buildings, based on an average seasonal outdoor temperature of 40°F.
18. 2011 New York City Housing and Vacancy Survey:
<http://www.census.gov/housing/nychvs/data/2011/ser1a.html>
19. 2014 Inventory of New York City Greenhouse Gas Emissions:
http://www.nyc.gov/html/planyc/downloads/pdf/NYC_GHG_Inventory_2014.pdf
20. This rating should be for the whole window, using procedures certified by the [National Fenestration Research Council \(NFRC\)](#).
21. The average vent free area for the building population examined in this study
22. 2013 Inventory of New York City Greenhouse Gas Emissions:
<http://www.nyc.gov/html/planyc/html/publications/publications.shtml>