playbook

Upgrading Insulation

Reduced energy waste, enhanced comfort

Solutions to common insulation challenges that save energy, minimize emissions, and increase occupant comfort.

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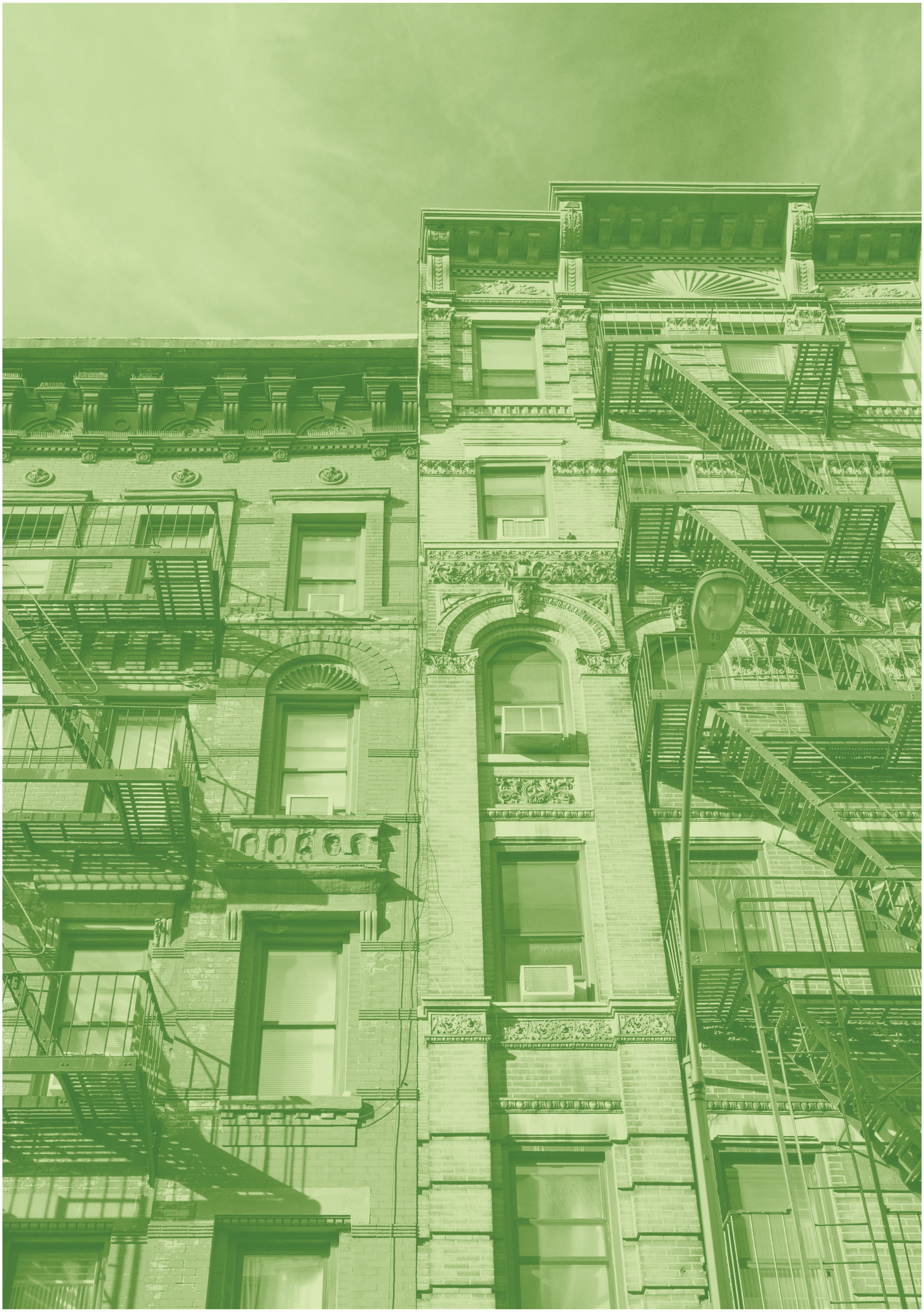


insulation: keeping the outside out

Many New York City buildings, particularly those built prior to the 1980s, were constructed with subpar insulation. Hard to reach areas have frequently been left uninsulated, with some buildings lacking insulation entirely, and thermal bridges have often gone unaddressed. This report offers solutions to common insulation challenges, presenting targeted improvements that should be considered during more comprehensive retrofit projects.

Insulation upgrades benefit building owners, tenants, and occupants. Subpar insulation leads to energy waste, increasing energy bills for both landlords and tenants. Thermal bridges (places where thermally conductive materials increase thermal transfer between inside and outside, see Fig. 2) exacerbate the problem. Poor insulation and thermal bridges also have an adverse effect on occupant comfort, causing building occupants to feel chilled near cold exterior walls and resulting in internal drafts that occupants perceive as a chill (see Fig. 1). Even imperfect insulation improvements can help mitigate these issues, offering significant cost savings and improved occupant comfort.

A building's envelope is made up of the exterior walls, roofs, windows, and doors separating conditioned interior spaces from the unconditioned outdoors, controlling the transmission of heat, air, water vapor, and moisture. While this report focuses on specific insulation upgrade scenarios, more general information on improving building envelope performance can be found in the following reports from BE-Ex's *Tech Primer* series:

- *Roof Insulation*
- *Wall Insulation*
- *High Performance Windows*

Envelope Control Layers

The transmission of heat, air, water vapor, and moisture across a building envelope is managed by a series of "control layers", including insulation, which must be correctly installed and coordinated in order to successfully create a protective enclosure. Each control layer interacts with, and influences, the others. Improper design or installation of control layers can result in the uncontrolled intrusion of water, air, and vapor, leading to occupant discomfort, high energy bills, and even structural damage. The control layers of an enclosure are as follows:

Thermal protection: The combination of materials (primarily insulation) which reduce heat loss and gain between conditioned spaces and the exterior. Materials used for thermal protection are characterized by their **R-value**, a measure of how well a material resists heat flow. Materials with higher R-values, indicating greater thermal resistance, offer superior performance to those with low R-values (see Fig. 3 for relative R-values of various insulation types).

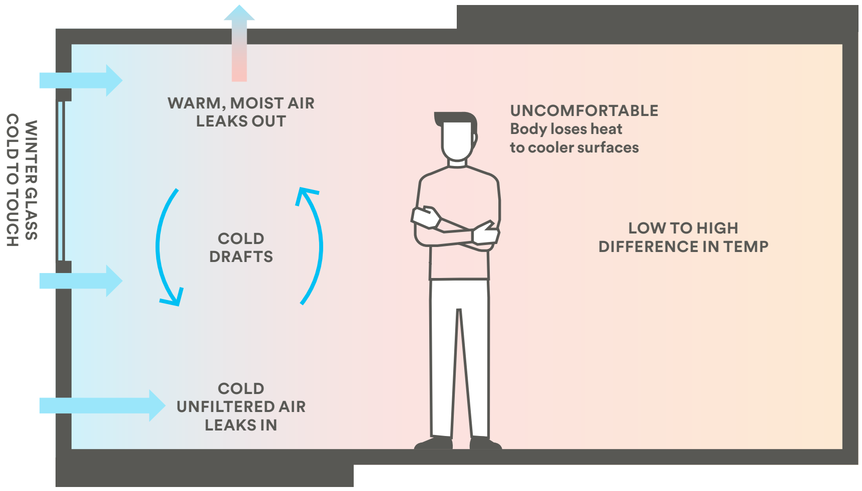
Air barrier: A continuous set of materials which prevent the movement of air through the envelope, including at penetrations, such as windows, doors, and vents. Ineffective air barriers are responsible for the vast majority of heat loss and moisture intrusion in typical buildings, undermining the effectiveness of insulation. Window and door assemblies are part of the air barrier, along with sealants, fluid and sheet membranes, and weatherstripping. Every building requires a continuous air barrier.

Vapor control: Distinct from the air barrier, the vapor control layer mitigates the diffusion of water vapor through building materials. The type and position of vapor control required is determined by the type of wall assembly, the local climate, and the anticipated pressure conditions. The importance of vapor control increases with the amount of insulation and level of airtightness.

Water barrier: The layer of materials, often a fluid-applied or sheet membrane, installed to keep liquid water out of the building interior.

This playbook focuses on the role of insulation in the thermal protection of the building, but how this component interacts with the other control layers must be carefully considered on a case by case basis.

Figure 1: Thermal Comfort



If the temperature difference is large enough between ambient indoor air temperature and poorly insulated exterior walls, an internal draft can result, causing building occupants to feel chilled even if ambient indoor air temperature remains constant.

Legislative Context

The passage of the Climate Mobilization Act (CMA) in April 2019 secured New York City's place as a global climate policy leader. With buildings responsible for nearly 70% of the city's greenhouse gas emissions, the CMA places limits on building emissions starting in 2024, resulting in an 80% reduction in building emissions levels by 2050 (compared to a 2005 baseline).

Meeting the CMA's stringent emissions limits will require pursuing energy savings with regard to every major building system. Insulation improvements directly impact both heating and cooling demand and are therefore a critical prerequisite to high performance. By reducing heat loss (and gain), mitigating uncomfortable drafts, and limiting the potential for interior condensation, properly designed and installed insulation plays a crucial role in minimizing energy use and associated greenhouse gas emissions.

Insulation Materials

Different insulation upgrades require different types of insulation. Some types of insulation are better suited to indoor applications, for example, while others are ideal for hard-to-reach locations. Below is a brief overview of different insulation types and their various applications.

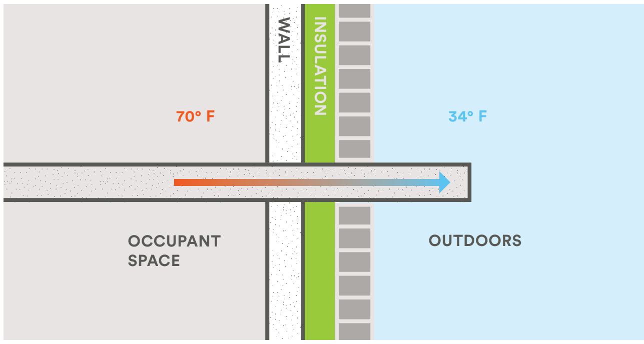
Rigid board insulation is most commonly made from petroleum-based foam products, as well as mineral wool and wood fiber. Thanks to its durability and water resistance, most rigid board insulation can be applied to building exteriors as well as interiors, making it a good option for a wide variety of applications.

Batts and rolls are made up of flexible fibrous materials, including fiberglass, mineral wool, and cellulose. This insulation type is very easy to install in conventional scenarios, being sized to fit standard spaces between studs and joists. These materials are not suitable for applications where moisture is an issue or where rigidity is required.

Loose fill insulation utilizes fibrous materials that are typically blown into place. Cellulose and fiberglass products are most common, but alternatives are available. Because it is blown into place, loose fill is a good fit for hard-to-reach locations where it would be difficult or impossible to apply rigid board, batt, or roll insulation.

Spray foam insulation consists of liquid based products that are sprayed into place. Though quick to install, these petroleum-based products include volatile organic compounds (VOCs), which are highly toxic and can be inhaled or absorbed through the skin. If mixed improperly, VOC off-gassing can continue after application, and there are additional health concerns associated with dust during removal or repair. While there are products advertised as "eco" based, they typically utilize oils that offset only a limited percentage of the petroleum base and may not significantly reduce the VOCs that result from blowing agents in the material.

Figure 2: Thermal Bridging



Thermal bridging occurs when certain building envelope components are more thermally conductive than their surroundings. These components allow heat to penetrate the building envelope, resulting in heat escaping occupant spaces in the winter and entering into them during the summer. Thermal bridging produces hot or cold spots on floors and walls that introduce drafts and increase the risk of condensation, mold, and other air quality issues. Thermal bridging can severely impact envelope performance, even in otherwise well-insulated buildings, and often goes unseen and unmanaged.

Figure 3: Types of Insulation

*Health Based Ranking (HBR): red – orange – yellow – pale yellow – green (Worse → Better)

	R/inch	Exterior	Interior	HBR*
Rigid Boards				
Extruded polystyrene	3.9-5.0	yes	yes	orange
Expanded polystyrene	3.1-4.5	yes	yes	yellow
Poliyisocyanurate	5.4-6.9	yes	yes	yellow
Mineral wool	3.4-4.2	yes	yes	pale yellow
Wood fiber	3.4-3.7	yes	yes	green
Batts/Rolls				
Fiberglass	2.7-3.2	no	yes	green
Cellulose/Cotton	3.5-4.0	no	yes	pale yellow
Mineral wool	4.0-4.3	yes	yes	pale yellow
Loose Fill				
Fiberglass	2.2-4.6	no	yes	green
Cellulose/Cotton	2.7-3.8	no	yes	pale yellow
Wood fiber	3.8	no	yes	pale yellow
Sprayed				
Spray Foam	3.5-6.9	yes	yes	red

Source: Healthy Buildings Network "Guidance for Specifying Healthier Insulation and Air-Sealing Materials" https://s3.amazonaws.com/hbnweb.dev/uploads/files/vKbS_NRDC-3094%20Specifying%20Healthier%20Materials%20report_05.pdf

Advanced Insulation

As local laws, progressive energy codes, and industry demands require ever more energy efficient buildings, new insulation materials have been created to meet this need. These materials have not yet been widely adopted in North America, in part due to relatively lax local insulation standards.

Some distinguishing characteristics of these advanced insulation materials include high R-values relative to weight and bulk, or an ability to add insulating capacity to standard materials, potentially improving their utility in challenging scenarios like those explored in this report. Examples of advanced materials include:

Aerogel – derived from a gel in which liquid has been replaced with gas, aerogel insulation comes in rolls or boards and offers extremely low thermal conductivity. Though costly, this material is attractive for applications in which only thin sheets are possible due to space constraints.

Insulating exterior plaster – applied by spraying or troweling onto exterior walls, insulating exterior plaster is a conventional lime plaster to which aerogel has been added, allowing for an extremely thin layer to provide notable insulation benefits.

Vacuum Insulation Panel (VIP) – consisting of a rigid core surrounded by a gas-tight enclosure, VIPs are rigid boards characterized by exceptional thermal resistance relative to panel thickness. Offering a combination of thin panels and high R-values, VIPs are a good fit where space is at a premium, but because they cannot be cut or punctured their application is quite limited thus far.

decision making process

Decision makers should not assume that the most obvious insulation solution is the best option, or even the easiest. In many cases, cost-effective, non-intrusive solutions can provide comparable energy efficiency benefits to the most obvious solutions.

Engaging in a discovery process is the first step in identifying optimal approaches to insulation retrofits. Older buildings in which complex insulation challenges are particularly common often lack accurate, detailed drawings. Determining exactly how a building is constructed is critical to identifying areas and components in need of insulation upgrades – and how any changes to insulation might impact air and moisture infiltration. This process involves determining the components and dimensions of wall and roof assemblies, pinpointing sources of thermal bridging, and evaluating both the physical properties and condition of construction materials.

The discovery phase is especially important in places like New York City, where much of the building stock was constructed prior to material standardization, and thermal properties of construction materials can vary widely. In many cases material evaluation requires testing building materials to determine their thermal and moisture properties, providing a fuller picture of a building's environmental performance.

Upon completion of the discovery process, decision makers will have a good sense of a building's insulation challenges, having identified under-insulated areas of the building and sources of thermal bridging. Using this information, potential insulation upgrade solutions can be identified and prioritized. Available solutions are often constrained by building owner preferences, including concerns about cost, aesthetics, and disruption to building occupants.

Cost constraints and unique architecture features often limit insulation retrofit options and make the highest levels of performance unattainable, but even minor insulation upgrades can significantly improve energy efficiency. With so many New York City buildings suffering from poor thermal performance due to subpar insulation and thermal bridging, retrofits should be focused on providing a first layer of protection, solving for major thermal bridging and improving overall envelope performance. Decision makers should not shy away from partial, imperfect solutions offering major energy efficiency benefits relative to current building performance.

Regulatory Concerns

In addition to architectural considerations, financial constraints, and owner preferences, regulations can significantly restrict viable insulation upgrade options. When determining where and how to upgrade a building's insulation, regulatory realities must be considered in conjunction with other features unique to a given building.

Property Lines With space at a premium in New York City, exterior building walls often abut property lines. While this approach maximizes usable space, it can limit the ability to add exterior insulation. Building owners cannot install insulation extending beyond their property lines, whether at street side – extending into public space – or into adjacent lots, violating neighbors' air rights. Scenarios where property lines are a consideration may require creative solutions, including adding insulation to the interior of the building.

Fire Code To prevent fire spread in New York City, the fire spread resistance of assemblies are rated and approved based on the adoption of national standards and testing of materials and assemblies. Allowable fire ratings for any particular material or assembly used in New York City are based on building location, height above the street, and context of surrounding buildings. Insulation selection can affect the achievable fire rating of any given assembly and can impact a project's compliance with fire code.

Landmark Laws New York City's landmarks laws play a valuable role in maintaining neighborhoods' historic character. In so doing, however, they also sometimes prevent landmarked buildings from utilizing certain insulation upgrade options. Façade repairs and improvements to landmarked buildings must typically match the buildings' historic materials and features, which often precludes the application of external insulation. Building decision makers should work with relevant authorities to find suitable solutions.

insulation upgrade scenarios

New York City's building stock is exceptionally diverse. With that diversity comes a number of unique insulation challenges pertaining to specific architectural conditions. Outlined below are solutions to some of the more common insulation challenges facing New York City buildings, including:

- Shared party walls
- Concrete slab balconies
- Parapets
- Bulkheads
- Unconditioned basements
- Cocklofts

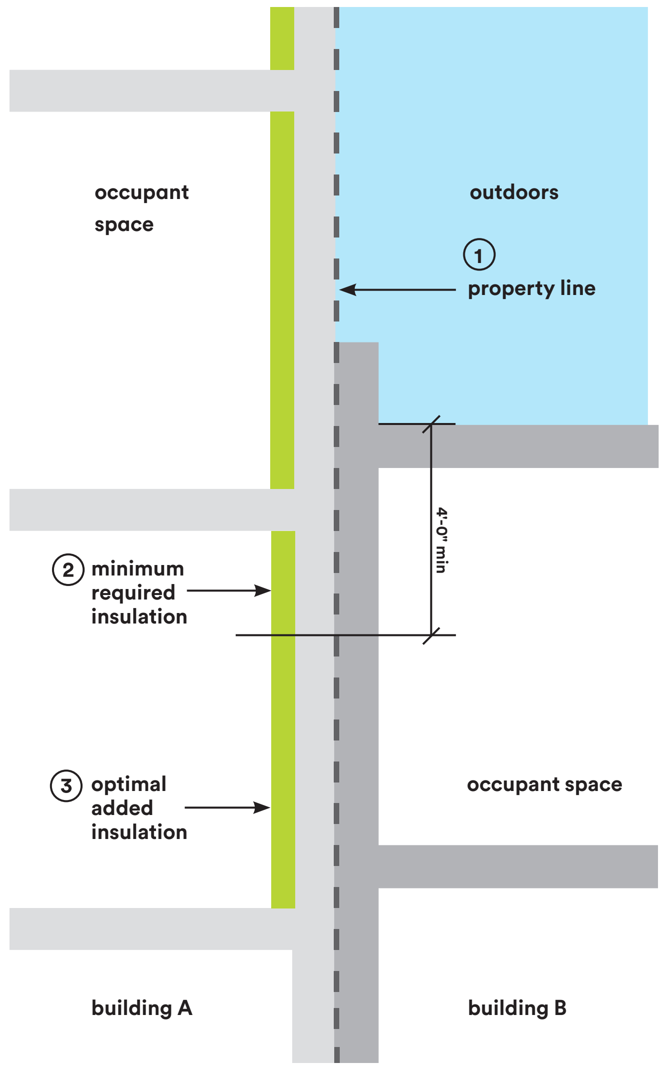
A Shared Party Walls

In scenarios where one building's shared party wall extends beyond that of a neighboring building, upgrading insulation presents a challenge. Where buildings share a party wall it is assumed that the interior spaces of both are conditioned, obviating the need for a thermal barrier (although air and vapor control layers are recommended). But where these uninsulated walls extend beyond those of a neighboring building they are exposed to the exterior and become a source of significant heat loss or gain, depending on the season.

Adding exterior insulation is the most effective fix, but is generally not an option, as most party walls are flush with the property line and adding insulation to the building's exterior would intrude on the neighboring property. Absent an agreement with neighboring owners, applying insulation to the interior face of perimeter walls offers the best opportunity to upgrade insulation.

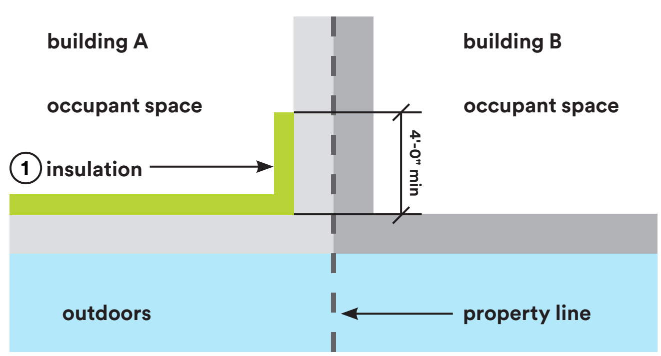
Insulation should be applied to the interior face of perimeter walls that are directly exposed to the

A Shared Party Wall Section



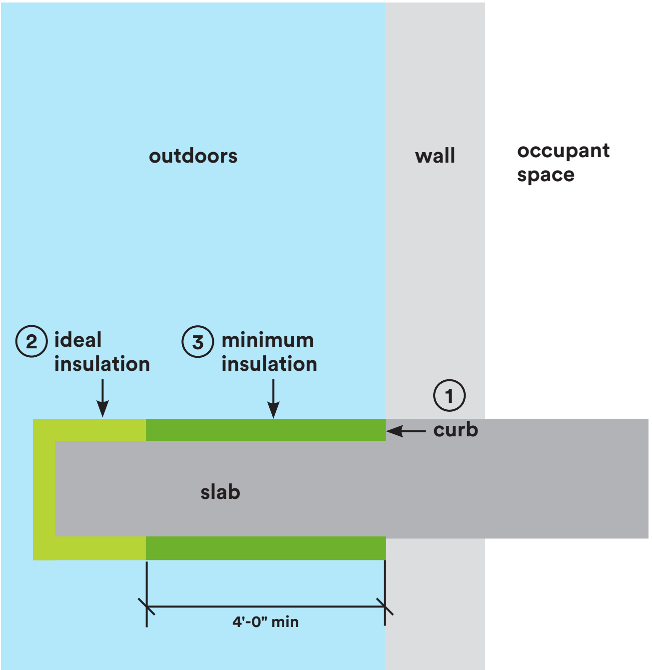
Property lines (1) generally prevent the installation of exterior insulation, so insulation should be installed along the interior of perimeter walls instead (2). At a minimum, insulation should be at least 4'0" below the highest plane of the conditioned space in the adjacent building. In cases where the 4'-0" minimum falls in the middle of the wall to be insulated, insulate the entire wall (3).

A Shared Party Wall Plan



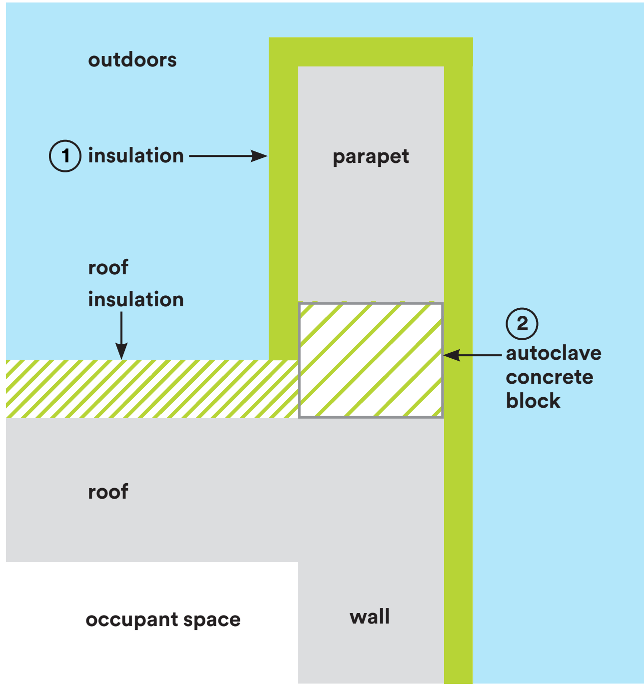
The insulation along perimeter walls (1) should be at least 4'-0" wide to prevent heat transfer through the neighboring building's facade.

(B) Concrete Slab Balcony



The ability to add balcony insulation is dictated by whether there is a curb (1) or stepdown from the building's interior, providing space to apply exterior insulation (2). Insulating the 4'-0" closest to the building's exterior wall is most critical (3).

(C) Parapet



Most buildings do not insulate the exterior face of the parapet. Upgrading insulation can involve wrapping the parapet in insulation (1), or adding a layer of autoclave concrete in the case of parapet reconstruction (2).

outside, as well as any spaces close enough to the exterior that cold spots or condensation might form on the interior. Determining how much insulation is needed requires specific analysis of conditions in a given building.

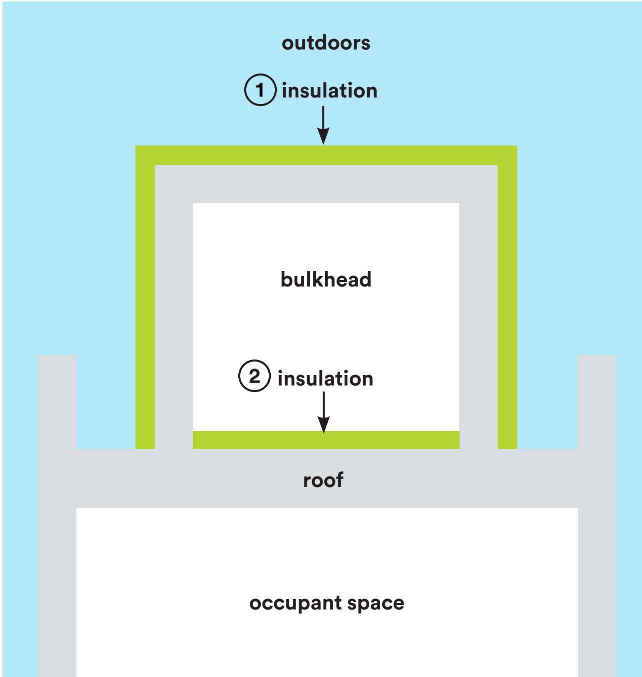
(B) Concrete Slab Balconies

Many New York City buildings feature balconies that are simply extensions of the concrete slab that forms the interior floor. Typically uninsulated, these slabs create major thermal bridges, allowing heat to transfer through the concrete and bypass adjacent wall insulation, even in otherwise well-insulated buildings. Mitigating thermal bridging resulting from slab balconies is a particularly challenging task, and available upgrade options are highly dependent on specific features of a particular building. Inset balconies offer a potentially straightforward upgrade option. In this scenario, an exterior wall can be added flush with the existing exterior wall, converting the balcony to an enclosed space. This approach eliminates the thermal bridge resulting from the balcony's slab, while also providing additional interior space (although this may require careful assessment of zoning regulations, as it increases the building's gross square footage).

Buildings with extruding, non-inset balconies and those with inset balconies where decision makers wish to avoid enclosing that space, have alternative upgrades available to them. Older buildings often have a curb or step down from the interior occupant space to the balcony. This arrangement affords space to apply a layer of insulation to the balcony's slab that wraps the sides and underside of the balcony as well, providing a layer of insulation that mitigates the concrete slab's thermal conductivity.

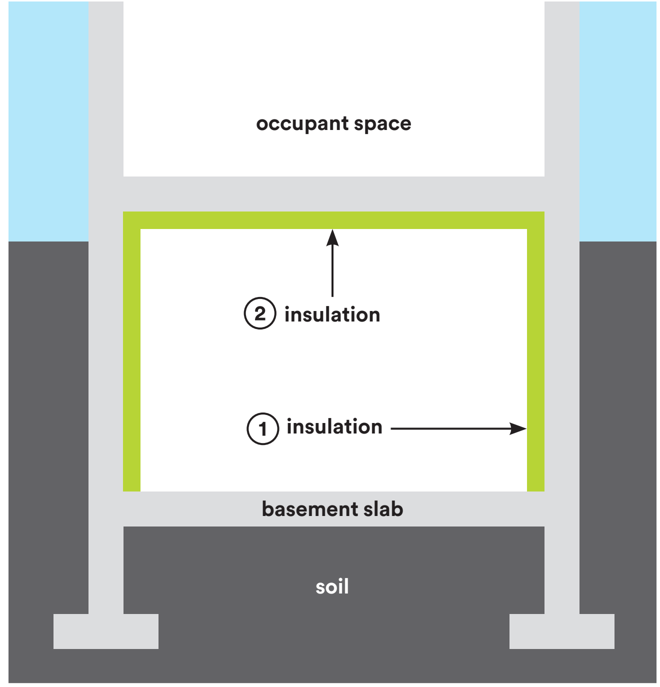
Wrapping the entire slab in insulation, while ideal, is often not feasible. Insulating a concrete slab offers the greatest benefit closest to the exterior wall, as this is the area where most thermal transfer occurs. Though it has higher thermal conductivity than insulation materials, concrete offers some thermal resistance in its own right, and the deeper the balcony, the longer it takes heat to travel from the leading edge into, or out of, interior spaces. As such, optimal insulation approaches can entail insulating the balcony from the exterior wall to some predetermined depth short of the leading edge, with 4' being a commonly accepted distance.

D Bulkhead



In most cases, bulkhead insulation creates thermal separation from the exterior (1). In cases where bulkheads house heat-generating mechanical equipment, they are insulated to prevent the intrusion of heat into occupant spaces below (2).

E Unconditioned Basement



Insulation is installed along perimeter walls (1) and, optimally, along the ceiling as well (2).

C Parapets

Common rooftop features in masonry buildings, parapets are an extension of a building's exterior wall at the edge of a roof. Parapet walls are generally uninsulated and constructed without a thermal break, making them a major source of thermal penetration. The most straightforward solution to insulating parapet walls involves wrapping them in exterior insulation on all sides. Ideally, this improvement is conducted when replacing a roof, minimizing cost and disruption. As with other retrofit scenarios, property lines can be a constraint, preventing the application of insulation to building exteriors.

In cases where major repairs to parapet walls are required, a layer of autoclave concrete or other material with low conductivity can be installed at the base of the parapet to function as a thermal break in lieu of wrapping the parapet in insulation.

D Rooftop Bulkheads

Bulkheads are rooftop structures used to house mechanical equipment, water tanks, and stairwells. This architectural feature takes many different forms in New York City, depending on its specific purpose, and optimal insulation solutions will vary.

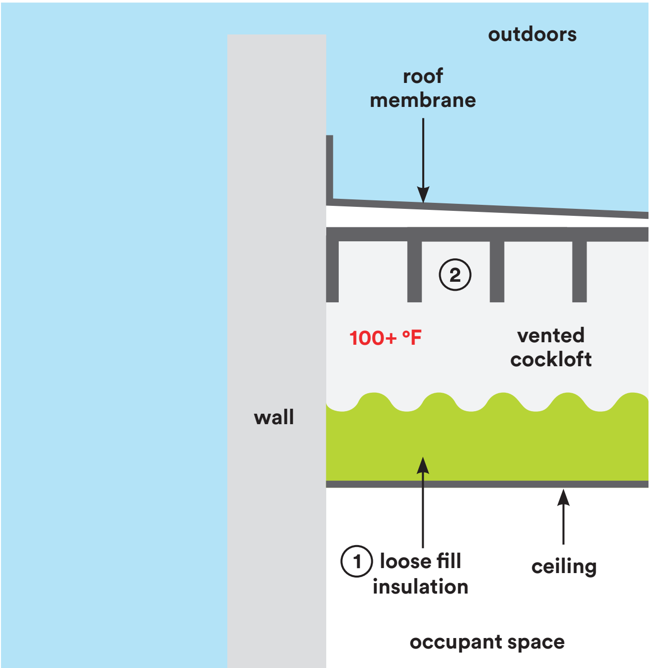
In some cases, upgrading bulkheads is a straightforward process of wrapping them in insulation. In others, however, bulkheads include large areas of louvers or air dampers, which may negate the benefit of insulating the rest of the bulkhead.

In cases where bulkheads house heat-generating mechanical equipment, the goal is often to thermally separate the bulkhead not from the exterior but from the occupied spaces below, preventing the intrusion of heat. Here the ideal location of insulation may be the floor, mimicking roof insulation, although this approach is typically feasible only if the bulkhead is being reconstructed or the equipment it houses is being replaced.

E Unconditioned Basements

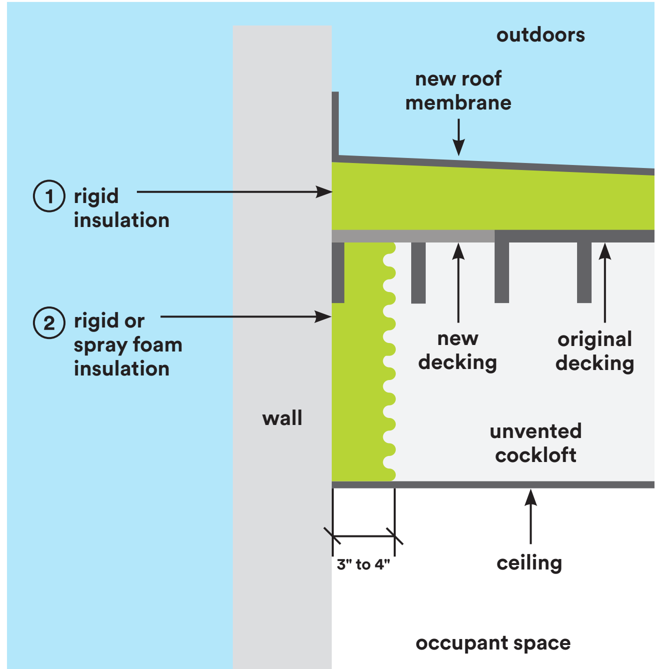
New York City's basements are often uninsulated. This is less of an issue in deeper basements, as below the frost line the earth is a relatively constant temperature of roughly 55 degrees F, but is quite problematic where basement walls are exposed to earth above the frost line or to the exterior. That said, to achieve optimal energy efficiency performance, insulating walls is highly recommended, even in deep basements.

F Cockloft Before Insulation Upgrade



Cocklofts typically rely on 6" to 12" of loose fill (1) spread across the top of the ceiling, with no insulation in the roof assembly itself (2).

F Cockloft After Insulation Upgrade



When upgrading cockloft insulation, rigid insulation is installed under the new roof membrane (1), and 3" to 4" of rigid insulation or spray foam insulation (2) is applied along inside faces of the walls of the cockloft.

In theory, upgrading basement insulation is a relatively straightforward process, involving the application of insulation to the interior face of perimeter walls and, optimally, along the ceiling. In practice this process can be quite complex, as basements house essential building systems like HVAC equipment, hot water, and electrical infrastructure, as well as tenant spaces like laundry and storage rooms, making access difficult. If access challenges render discontinuous insulation the only upgrade option available, it will still help improve a building's energy performance.

F Cocklofts

Common in older masonry rowhouses and multifamily buildings, cocklofts are small attics above occupant spaces. Typically the “floor” of this attic is the ceiling of the rooms below, with a sloped roof above that often sits just a few inches above the ceiling at the rear and as much as 3' or 4' at the front. If insulated at all, the most common insulation is loose fill spread across the top of the ceiling at a depth of 6" to 12” (with no insulation in the roof assembly itself). The space between the loose fill and the roof is ventilated with a mushroom cap or sidewall vent, with temperatures regularly rising above 100 degrees F. Access to these spaces is a challenge.

The most common upgrade involves opening the ceiling from below and blowing in new loose fill over the old, which can lose its loft over time due to age and moisture. The most effective upgrade is performed at time of roof replacement. In this case, several inches of new rigid insulation is installed under the new roof membrane. During construction, roughly 24” of perimeter decking is removed and 3" to 4” of rigid or spray foam insulation is applied along the inside faces of the walls of the cockloft to protect the attic from the exterior or unconditioned spaces of adjacent buildings.

Conclusion

The complex insulation scenarios outlined in this report often do not allow for comprehensive, high performance insulation upgrades. Decision makers should focus on adding insulation where and when they can, as even minor upgrades can reduce energy waste, avert emissions, and improve occupant comfort in previously uninsulated spaces.

Assistance is available to help guide you through the process of upgrading your building's insulation. You may also qualify for financing and incentives to help reduce the cost of improvements. The NYC Accelerator's team of Efficiency Advisors can help you find the right resources for your building.

The NYC Accelerator

The NYC Accelerator offers free, personalized advisory services that streamline the process of making energy efficiency improvements to buildings. The Accelerator's team of Efficiency Advisors are building and energy experts who can help you develop a custom energy efficiency plan, including identifying incentives and financing to help you upgrade your insulation and supporting your project every step of the way.

To get help today, call (212) 656-9202 or visit nyc.gov/retrofitaccelerator.

NYC Energy Efficiency Corporation (NYCEEC)

NYCEEC is a non-profit specialty finance company that develops financing solutions to enable projects that save energy or reduce greenhouse gases. NYCEEC's custom-tailored solutions close financing gaps for buildings and lean energy project developers. NYCEEC can help you explore options for financing insulation upgrades.

- nyceec.com

Incentive Providers

The New York State Research and Development Authority (NYSERDA) offers incentives for insulation upgrades. Customers of Con Edison and National Grid may qualify for incentives for many insulation improvements.

- nyserda.ny.gov
- coned.com/energyefficiency
- nationalgridus.com/services-rebates

Further Reading

To learn more about the topics covered in this brief, please visit:

- be-exchange.org/resources/

The NYC Accelerator offers free advisory services to streamline the process of making your building energy efficient. The NYC Accelerator is committed to helping every building in our city save money and ensure a cleaner, more energy efficient future.

phone: (212) 656-9202
web: nyc.gov/retrofitaccelerator

The Building Energy Exchange is a center of excellence dedicated to reducing the effects of climate change by improving the built environment. BE-Ex accelerates the transition to healthy, comfortable, and energy efficient buildings by serving as a resource and trusted expert to the building industry.

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