27 Maintain Habitable Temperatures Without Power

I. Summary

Issue:
Utility failures often disable heating and cooling systems, leaving interior building temperatures dependent on whatever protection is provided by the insulation and air sealing of a building's walls, windows, and roof.

Recommendation:
Extend the mandate of the Task Force through Fall 2013 to develop a multi-year strategy for ensuring that new and existing buildings maintain habitable temperatures during utility failures. Clarify requirements for tightly sealing new windows and doors and upgrading roof insulation during roof replacement.

II. Proposed Legislation, Rule or Study

Extend the Mandate of the Building Resiliency Task Force:

Extend the mandate of the Building Resiliency Task Force through Fall 2013 to develop a five-year strategy for our codes, construction practices, and building materials to achieve or surpass current international best practice standards on envelope performance. Explore options for improving upgrades to existing buildings, including requiring contractor education and expanding inspections to include window replacements. Eventually, building envelopes on all new construction should achieve the following minimum R-values and air tightness based on international best practice:

- Wall R-values of R-25
- Roof R-values of R-50
- Window assembly R-values of R-4.3
- Air tightness of less than 1.5 ACH at 50 Pa.

Amendments to Department of Buildings Bulletin 2011-15:

1. Amend paragraph 3(a)(ii) as follows:

   ii. Sheathing or decking exposed. Where alterations, renovations or repairs performed on a roof or roof setback expose the sheathing or decking, <u>air sealing shall be required that conforms to the requirements in Section 402 of the NYCECC and</u> insulation shall be required either above or below the sheathing or decking in accordance with Section 101.4.3, Exception 5 of the NYCECC. This may require construction at the parapet, bulkhead, etc., to meet New York City Building Code ("NYCBC") requirements. However, if provisions of the New York City Zoning Resolution preclude insulating above the sheathing or decking and there is a practical difficulty with insulating below the sheathing or deck, insulation of such roof plane shall not be required; in such a case, the applicant shall provide other measures to mitigate the calculated thermal loss of the noncompliant roof repair, in either site energy or the calculated energy cost.

2. Amend paragraph 7 as follows:

   7. Sealing. All envelope work, including work performed on the exterior wall of interior renovations, shall be sealed in accordance with Section 402.4 and/or 502.4 of the NYCECC. <u>Any replacement window, door, or skylight must be sealed to limit infiltration in accordance with Section 402.4.1 of the NYCECC</u>

Best Practices for Existing Buildings:

Building owners that are planning extensive renovations should consider advanced performance targets for envelope performance, such as the standards set by Passive House or the Army Corps of Engineers. If renovations are not planned, buildings should undergo an energy audit or be evaluated by an air sealing specialist to develop a targeted plan for phasing building envelope improvements into their building operations plan. Particular attention should be given to vents above elevator shafts.

III. Supporting Information

Expanded Issue and Benefits:

Twenty percent of New York City experienced a blackout during the two days following Superstorm Sandy, leading most to lose heating. Heating systems generally require some electricity to function, whether to run pumps or power fans to blow warm air. Fortunately, temperatures did not drop below 40 degrees in the week following Sandy because it was during a shoulder season. However, temperatures in the city can be extreme: the week of January 21, 2013 experienced five days with lows of 11-15 degrees, while temperatures were 92 degrees or higher during the week of July 4, 2012. Widespread blackouts have a long history in the city, with major blackouts occurring in 1965, 1977, 2003, and 2012.

Widespread power failures affect far more residents than the city can be expected to shelter and many will choose to remain in their homes. According to an analysis conducted for the Building Resiliency Task Force, there is a direct connection between the level of insulation and air sealing in a building's facade and the internal temperature of the building. The thermal performance of the building envelope is particularly critical in the depth of winter or height of summer as it determines how long a residence is habitable without active heating or cooling. The analysis showed that when outdoor temperatures are below freezing, the internal temperature in a poorly insulated building with high infiltration rates and no functioning heating will plummet by 15 degrees within hours, to near freezing in a number of days.

In order to improve the ability of buildings to maintain habitable temperatures in the event of a utility failure, this proposal recommends approaches for improving building envelopes in both new construction and existing buildings. For new buildings (and upgrades to major façade elements), the proposal is to extend the mandate of the Building Resiliency Task Force to develop a strategy for New York City's façades to achieve or surpass current international best practices. For existing buildings, the proposal clarifies existing requirements under the energy code. The proposal also recommends best practices for existing building retrofits.

New Buildings

New buildings that meet the standards of the current New York City or New York State energy codes perform much better than older buildings whose construction followed less stringent requirements. Nonetheless, there is still significant room for improvement of the standards for new building construction. Numerous buildings in the U.S. have demonstrated that more progressive façade design and construction leads to far better performance than currently typical, and in Europe voluntary standards like Passive House have demonstrated the substantial benefits of high performance envelopes for decades.

In the US, many larger buildings comply with the energy code using a "whole building performance" approach that allows the buildings to "trade off" lower performance façade systems against improvements to other building systems. While this relative performance approach can meet short-term objectives of reduced energy consumption, it does not address resiliency concerns and is much less stringent than standards elsewhere. As a result, most new building envelopes in the city perform well short of their potential. More progressive jurisdictions (such as Finland, Germany, Switzerland, and Japan) improve on this relative performance approach by setting energy intensity targets for each building. These standards also commonly include minimum requirements for individual building components that are higher than US standards. Among of the most relevant examples of this discrepancy are the thermal performance requirements for various building elements, some of which are outlined in the following tables:

Jurisdiction	Wall R-values
Finland	R-22
Germany	R-23
Switzerland	R-28
Passive House (Typical Performance)	R-28-56
US	R-20

Jurisdiction	Roof R-values
Finland	R-35
Germany	R-35
US	R-49

Jurisdiction	Window Assembly R-values
Germany	R-4.3
Switzerland	R-4.3
US	R-2.8

These more progressive standards also address the air tightness of building envelopes, a significant contributor to the relatively poor performance of US buildings. In Germany, for instance, buildings with ventilations systems must have no more than 1.5 air changes per hour (ACH), while in Finland the threshold is even lower at 1.0 ACH, and 0.6 ACH for Passive House certified buildings. (In each case the building is tested under an air pressure of 50 Pa.)

Within the next year, New York State and New York City are expected to adopt the 2012 International Energy Conservation Code (IECC 2012), which will significantly improve building envelope requirements but still falls short of the best practice standards listed above. Moreover, trade-offs between building systems will still be permitted.

Within 5 years, NYC should improve the standards for building envelopes to ensure both energy efficiency and resiliency for all new buildings. Learning from existing national and international standards and voluntary rating systems, the city should develop improved standards that have a proven benefit and are appropriate for the building stock and climate conditions of New York City. The resulting improvements will include changes to existing codes, construction practices, and materials. Such measures should move towards increased levels of insulation and air tightness, including higher performing windows and frames. Significant improvement to curtain walls will be possible with new mullion designs that include composite materials or other means to reduce heat transfer. Energy recovery ventilation should be considered to ensure high indoor air quality and control moisture in buildings with improved air tightness. Building envelopes should be required to meet minimum standards, regardless of other energy trade-offs. These measures will require integrated, well-balanced evaluation to ensure an approach that optimizes performance while meeting economic, construction and operational objectives.

Existing Buildings

Most existing buildings have poorly insulated envelopes. Research conducted by Urban Green Council for their "90 by 50" study reveals that the walls of existing residential buildings have an average R-value of well below R-10. Experts estimate that typical curtain walls have an R-value of only 2 to 3. The problems with existing façades are legion, including: air leakage via old caulking and window frames; single-pane glazing; improperly and sporadically applied insulation, including thermal bridging in the insulation layer (through materials like metal studs); exposed concrete slab edges; aluminum window frames and curtain walls without thermal breaks; and large areas of glass without insulating coatings.

Under Local Law 85 of 2009, which created the NYCECC, any alterations to existing buildings must meet the relevant portions of the code for new construction. The Department of Buildings (the “DOB”) issued Bulletin 2011-015 to clarify how these code provisions apply to building envelopes. The bulletin specifies that roofs must be insulated when the roof sheathing decking is exposed during construction and states generally that envelope work must meet Energy Code air sealing requirements. However, anecdotal reports suggest that proper air sealing practices are often not followed during window, door, and roof replacements. As a result, this proposal recommends clarifications to the DOB bulletin.

Proper window installation requires sealing of the rough opening, a component of the building envelope that is only accessible during such window replacement. It is also important that windows and doors are installed in a manner that will ensure that factory-installed weatherstripping is effective and durable to seal against infiltration. Doors are often installed in a manner that allows continued infiltration owing to poor installation practices or inadequate weatherstripping (i.e. the weatherstripping still allows a gap to exist where there should be a full seal).

Roofs are the biggest source of air leakage and heat loss in most buildings. This is because the upper portions of the building are normally subject to the greatest natural pressure differentials, owing to stack effect (hot air rising through the building) and wind loading, both of which increase in magnitude with height. Roof replacement represents a unique upgrade opportunity because the construction process exposes the roof cavity, which is often otherwise inaccessible.

Enforcement & Education
Improving compliance with our building and energy codes is a critical component of achieving New York City's sustainability goals as well as ensuring health and safety and the overall resiliency of our community. After all, codes are merely words on paper if no one complies with them. The U.S. Department of Energy regards energy code compliance so highly that receipt of their energy stimulus grants is contingent on jurisdictions demonstrating a 90% compliance rate.

There are two primary aspects to increasing compliance rates. First, one can improve the level of knowledge within the design and construction community through education. California has taken this approach to energy code compliance for decades by providing training and resource centers, and it has achieved generally positive results. Second, a robust system of review and enforcement is required to ensure that the codes are taken seriously.

The Department of Buildings began robust enforcement of the Energy Code in 2011, including the creation of a detailed inspection checklist. It is in the midst of adding many staff to its Energy Code enforcement unit. Meanwhile, with NYSERDA funding, Urban Green Council developed energy code training for architects and engineers, which was delivered to thousands of design professionals in cooperation with AIA NY.

Not all energy-related construction requires a permit from DOB. Of particular interest to this Task Force proposal are window and door replacements, which require no permits or inspections. Sophisticated owners have the staff and internal processes to ensure such replacements are installed properly. However, many other building owners, such as coops and homeowners, do not have the expertise to review and assess the quality of such installations. As a result, this proposal recommends the study of these types of façade upgrades to determine how best to ensure quality work, such as using technologies like thermal imaging.

Given the rapid strengthening of the Energy Code, it is likely that the gap between construction practices and code requirements will grow without a significant investment in contractor education. In particular, standards for air tightness and insulation will require contractors to use improved wall assemblies and follow new practices to prevent air leakage. These techniques are not necessarily more complicated than past practice, but require education of a significant number of tradespeople. Also, unlike systems like lighting that can easily be improved at a later date, building façades are rarely upgraded so it is essential that upgrades or new construction are performed to a high standard. For this reason, the proposal recommends requiring contractor education as part of a multi-year plan to improve New York City building envelopes.

Implementation:

Best Practice Retrofit
There are many opportunities to improve air sealing and insulation in existing buildings, listed here and explained in more detail in following sections. The most effective strategies for multifamily residential buildings include:

- Seal open elevator shaft vents.
- Seal passive stairwell vents.
- Seal accessible side wall penetrations through the building envelope, particularly window/sleeve AC units, PTAC penetrations, plumbing penetrations, electrical service penetrations, electrical junction boxes, outlets, and switches.
- Seal interior partitions, chases, penetrations, and vertical and horizontal air leakage pathways to promote compartmentalization of the building, which will reduce heat loss and make the building habitable for longer periods.
- Weather seal loading docks to restrict infiltration when vehicles are parked in the doorway of the loading dock, in accordance with NYCEEC Section 502.4.5.
- Require vestibules at all entrance doors, including lobby doors, and require such a vestibule to be added during any lobby renovation or repair or alteration to an entrance door. Revolving doors are also an option where space is limited.
- Seal all air leakage pathways between garages and adjacent occupiable spaces, and insulate these partitions like an exterior wall.
- Seal all air leakage pathways between adjacent occupiable spaces and untempered mechanical rooms such as boiler rooms, MEP equipment rooms, meter rooms, and any other system or service rooms.

Elevator Shaft Vents
Elevator buildings typically have enormous holes in the form of open vents at the top of elevator shafts. These open vents are substantial causes of air infiltration and drivers of the stack effect; indeed, it is often difficult to open the front doors of elevator buildings because substantial volumes of air continuously exit the building through these vents, creating "suction" at the lobby doors.

These holes are due to building code requirements that elevator shafts be capable of venting smoke and hot gases through open vents, mechanical ventilation, air pressurization, or alternate means.[i] The NYCECC now limits these options for new construction by requiring the vents to be entirely covered with smoke-actuated motorized dampers.[ii] However, all but the newest buildings have generally opted for open vents because of lower first costs. Under the building code, each elevator shaft is required to have a vent that is at least three sq. ft. per elevator car. A building with five elevator cars will have a hole the equivalent of approximately 15 sq. ft. open year round, typically located at the roof level. Two-thirds of the opening can be closed by a smoke-activated mechanical damper or breakable glass, greatly reducing the size of the hole and minimizing the impact of air infiltration.

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i. NYC Building Code: 3004.6
ii. Section 502.4.4 of the NYCECC holds that "[O]utdoor intakes and exhaust openings…stair and elevator shaft vents and other outdoor air intakes and exhaust openings integral to the building envelope shall be equipped with not less than a Class I motorized, leakage-rated damper with a maximum leakage rate of 4 cfm per square foot (6.8 L/s *m2) at 1.0 inch water gauge (w.g.) (1250 Pa) when tested in accordance with AMCA 500D."

During an average NYC winter an elevator shaft with a three square-foot hole will leak $5,300 in heat.[iii] Reducing the vent opening by two-thirds would save approximately $3,500 annually in heating costs. It is estimated that this condition affects over 4,000 buildings in NYC – retrofitting every building with this condition could generate substantial energy savings.

NYC Building Code Section 3004.6 provides prescriptive methods for minimizing the open vent area at elevator hoistway enclosures. The least expensive and most cost-effective option is to cover two-thirds of the vent area with annealed glass, leaving the remaining one-third area open or on an openable, hinged damper. The more expensive option is to install smoke-actuated mechanical dampers that remain fully closed unless there is a smoke event.

Window & Door Sealing

Per section 402.4.1 of the NYCECC, all components of the building thermal envelope must be durably sealed to limit infiltration. Prescriptive language in the code section notes that the building component should be "caulked, gasketed, weatherstripped, or otherwise sealed with an air barrier material, suitable film, or solid material." Best practice examples include:

- Sealing the rough openings around a window with foam backer rod gasketing, caulk, and/or low expansion urethane foam;
- Caulking around the interior and exterior of a replacement window to ensure that moisture and air cannot enter the wall assembly;
- Verifying appropriate installation of all installed weatherstripping to ensure that a durable seal has been formed.

Roof Air Sealing & Insulation

Many residential buildings (especially smaller ones) include an attic space between the highest occupied rooms and the roof structure. At the time of roof deck replacement, this attic cavity below becomes accessible and upgrades to the building thermal envelope can performed. Some of these spaces are vented; others are not.

Vented Roof Assemblies

In these cases, the floor of the attic space (or alternatively, the ceiling of the highest occupied space in the building) typically marks the boundary plane separating conditioned and unconditioned spaces; when this space is accessible because of the removed roof deck, the attic plane should be thoroughly sealed with durable air impermeable materials (i.e. spray foam, rigid foam insulation board, silicone caulk, etc.) to eliminate the movement of conditioned air into the attic space. The objective is the creation of a continuous air barrier between conditioned spaces and the attic. Critical areas that require air sealing in this configuration are open wall cavities, mechanical service chases, and any other electrical, plumbing, or service penetrations that may allow conditioned air to escape into the attic space. Only after this air barrier is in place should code compliant levels of insulation be installed. The current NYCEEC calls for R-37 assembly in an attic space.

Code compliant attic ventilation should remain intact following this retrofit.

Unvented Roof Assemblies

With an unvented roof assembly, the building thermal envelope is considered to extend from the perimeter walls of the attic cavity to the level of the roof deck (with the insulation layer being rigid foam board type laid on top of the decking).

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iii. Steven Winter Associates estimates that a 3 square foot open hole across the top of the building drives approximately 255 mmBTU of heat loss. Energy loss estimates are based on current fuel rates, using a weighted average of fuel, gas, and steam based on actual consumption.

In many unvented attic situations the perimeter wall of the cavity is not properly insulated. This exterior wall should be insulated to NYCEEC requirements (R-11). Spray foam would be the most common application for insulating the exposed interior face of these exterior walls.

The roof should then be insulated to NYCEEC compliant levels (R-21 for continuous above deck insulation; R-37 for other applications). Typical options include the installation of above deck rigid foam, and the installation of spray foam at the underside of the roof deck and rafters from the inside of the attic cavity.

Passively Vented Stairwells
This proposal recommends that, by 2023, buildings with passively vented stairwells minimize infiltration by fully closing the net free area of all stairwell vents, in accordance with NYC Building Code Section 910.5.2. Similar in nature to the elevator hoistway enclosure vents discussed above, many buildings have passive vents at the top of stairwells intended to discharge smoke in the event of a fire. The Building Code allows for the retrofit of a damper that fully closes, provided that it will open when subjected to a temperature of 160F or to a rapid rise in temperature of 15F-20F per minute. As a best practice, stairwell vents should be retrofitted with a damper that fully closes and is either connected to a fusible link or controlled mechanically to open as required.

Sidewall Penetrations
All accessible sidewall penetrations through the building envelope should be durably sealed to limit infiltration. Particular attention should be paid to sealing room air conditioners, packaged terminal AC systems (PTACs), plumbing and electrical penetrations, and electrical boxes (receptacles, switches, etc.). These penetrations are subject to less differential pressure than those at the top and bottom of a building, but the interaction of wind, ventilation system performance, and stack effect can still drive significant volumes of air through even small sidewall leakage pathways. Sealing these gaps will allow for enhanced interior comfort and improved energy efficiency.

Compartmentalizations
Air sealing a building for compartmentalization is recognized by the high performance building design community as a particularly effective method of minimizing infiltration. Compartmentalization is the complete pressure isolation of an interior zone from spaces adjacent to that zone, with the intention of preventing the transfer of air or smoke between zones. Functionally, this means that all vertical and horizontal penetrations between apartments or between a unit and common spaces — even if they are interior to the building —be sealed to prevent the uncontrolled flow of air between these zones. The sealing and weatherstripping of other building interior components, such as stairway doors and vertical and horizontal chases, should also be encouraged, as should the installation of elevator vestibules at each floor and the implementation of zoned ventilation systems. Compartmentalizing a building is also considered a best practice because it reduces total air change rates by minimizing the impact of the stack effect and it effectively allows a building to remain habitable for a longer period of time during a service outage.

Loading Docks
Many buildings have loading docks as the central access point for deliveries. The use of loading docks is unavoidable during the winter months, and the loading dock doors often remain open for extended periods of time as deliveries are made. The top and bottom of buildings are the physical locations subject to the greatest stack effect pressures, and an

open loading dock door represents a massive hole in the envelope. It is not uncommon for over 50,000 cubic-feet-per-minute (CFM) of outside air to infiltrate the loading dock of a tall building on a cold day. NYCEEC Section 502.4.5 requires that “cargo doors and loading dock doors shall be equipped with weatherseals to restrict infiltration when vehicles are parked in the doorway.” The availability of new products make this a measure that should be widely pursued to minimize the impact of uncontrolled infiltration.

Exterior Entrance Doors
All entrance doors should either be of the revolving type or should have an effective air lock vestibule installed. In accordance with NYCEEC Section 502.4.6, vestibules shall be designed so that in passing through the vestibule it is not necessary for the interior and exterior doors to be open at the same time. It is not uncommon for 50,000 CFM of outside air to infiltrate the building while entrance doors are open.

Parking Garages
Parking garages are typically open to the outdoors and are often adjacent to occupied areas of a building, representing myriad opportunities for air leakage. As such, the garage is a critical building component to seal and compartmentalize. Sealing a garage prevents carbon monoxide and other car exhaust fumes from entering a building and can substantially reduce levels of air infiltration, yielding improved efficiency and comfort.

Cost:

Turner Construction Company did not perform cost estimation for this proposal. The following analysis was provided by the authors of this proposal:

There are no cost impacts to extending the mandate of the Task Force. For other strategies already required under the energy code or recommended in this proposal:

Windows: There should be no measurable difference in cost to properly seal a window at the time of installation. Window manufacturers specify how and where to seal a window or door in their installation instructions. Window replacements should follow manufacturers’ specifications, and thus the caulk/foam/sealants should be included within the cost of the project.

Roof air sealing and insulation: Effectively air sealing and insulating a vented roof assembly using common air sealing materials and cellulose insulation typically costs between $5-$7/sq. ft. of attic area, although the price will vary. The unvented option is more likely to cost $10-$15/sq. ft. of attic area, with more variables at play.

Elevator dampers: Building owners may expect to pay approximately $6,000 per vent for the motorized damper option, assuming electrical service is available at the roof level, and approximately $1,000 per vent for the annealed glass option. Each measure also yields cost benefits through reductions in heat loss to the exterior.

Sources:

1. NYCECC 402.4.1
2. NYS IECC2010 101.4.3