urban green

U.S. GREEN BUILDING COUNCIL CHAPTER

FEBRUARY 2014

BABY IT'S COLD INSIDE

Urban Green Council
Urban Green Council, the U.S. Green Building Council of New York, is a nonprofit dedicated to advancing the sustainability of urban buildings through education, advocacy, and research. Our educational programs range from technical workshops for architects and engineers, to outreach to thousands of building owners on major new New York City laws, to GPRO, a national training and certificate program for building trades, contractors, and operators. With our in-house technical staff and network of expert members and pro bono consultants, Urban Green Council is a center for urban green building policy development, leading the NYC Building Resiliency Task Force and the NYC Green Codes Task Force.

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SUMMARY

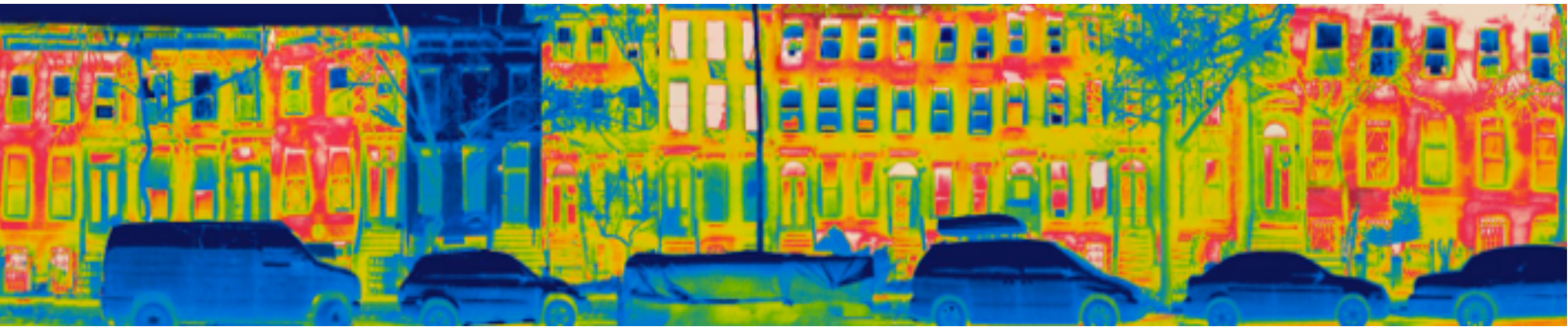
Over one million New Yorkers were plunged into darkness after Superstorm Sandy, and hundreds of thousands were without power for days or weeks.[1] But it could have been worse. During the blackout, temperatures were above freezing at night and in the 40s and 50s during the day. What if the power outage had occurred during a winter cold spell or summer heat wave? As part of the Building Resiliency Task Force,[2] Urban Green Council worked with environmental design consultants at Atelier Ten to study this question.

Our study found that during an extended winter blackout, the temperature inside a typical single-family house would be 35°F after three days. A typical high-rise apartment would drop to 45°F after three days, and then keep falling. A high-performing building that has better windows, fewer air leaks, and more insulation would do much better. After three days without power, a high-performing single-family house would stay above 60°F. And a high-performing high-rise would stay well above 50°F for more than a week.

In a summer blackout, temperatures in a typical all-glass apartment building would jump to almost 90°F, eventually rising to above 100°F. But a high-performing brick high-rise building would keep interior temperatures below 85°F for a week.

History shows that many people remain in their homes during extended blackouts. Without electricity, buildings are dependent on whatever protection is provided by their walls, windows, and roof. In today's buildings, that protection is modest at best. If it wore clothing, the typical New York City building would have a light jacket on—not what you'd wear outside in winter, and certainly not performance wear.

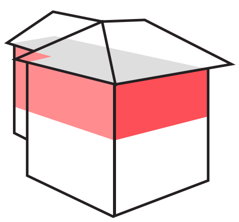
In the near future, heat waves will last longer and bring higher temperatures more often. There will continue to be power failures affecting large swaths of the city, and these failures may occur during severely hot or cold weather. Only some of our existing buildings are constructed well enough to maintain their indoor temperatures without power. But to protect all New Yorkers, these resilient, high-performing buildings must become the new normal.



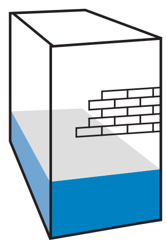
This thermal image shows how the dark blue super-insulated Brooklyn row house loses less heat than its neighbors.

RESULTS

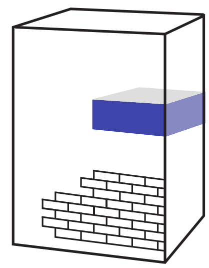
Computer models based on six representative residential[3] building categories were used to find indoor temperatures after a blackout. Summer and winter scenarios were defined by recent New York City weather data[4] and model both typical existing and high-performing buildings.[5] The Technical Appendix describes these models in detail.[6]



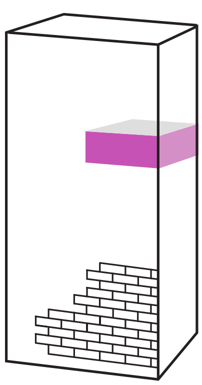
Single-Family House



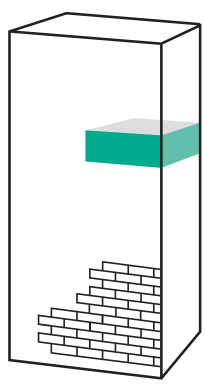
Row House Apartment



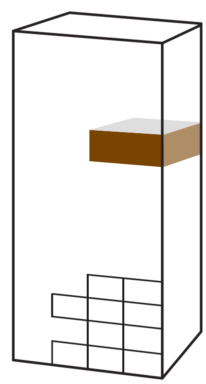
Brick Low-Rise Apartment



Pre-2000 Brick High-Rise Apartment



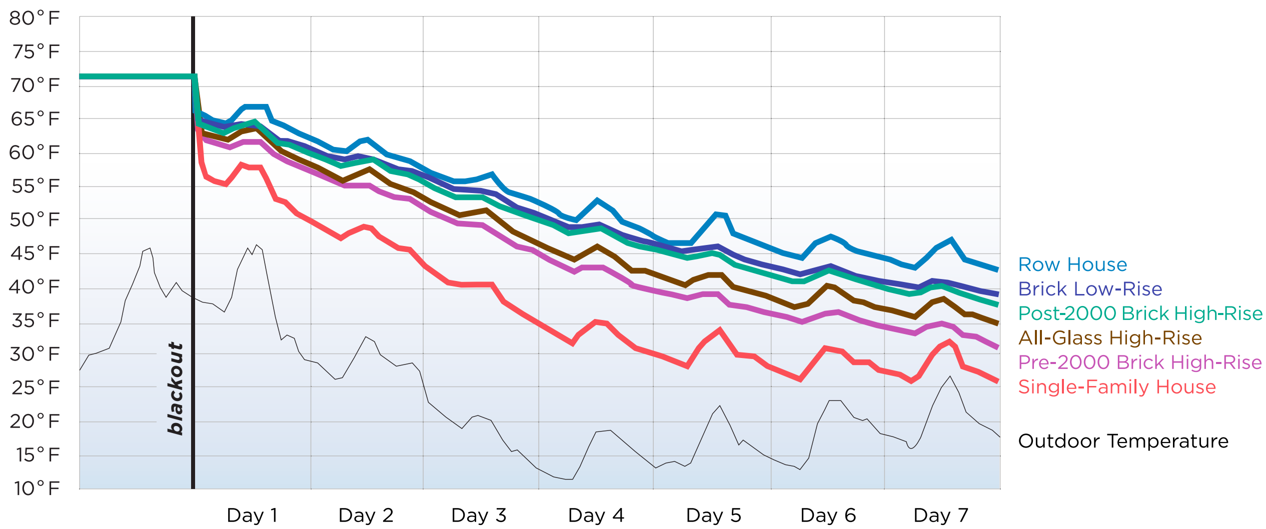
Post-2000 Brick High-Rise Apartment



All-Glass High-RIse Apartment

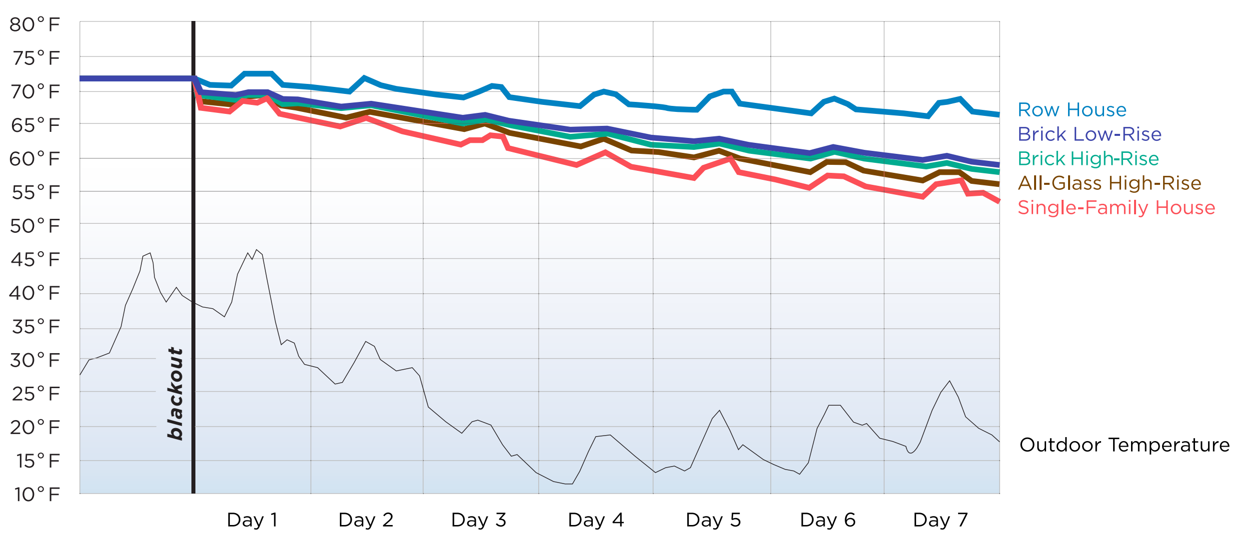
Indoor Temperatures During a Winter Blackout

Typical Building



A typical detached single-family house would fall below freezing on the fourth day. After a week, all the other buildings would be almost as cold, between 32°F and 43°F indoors.

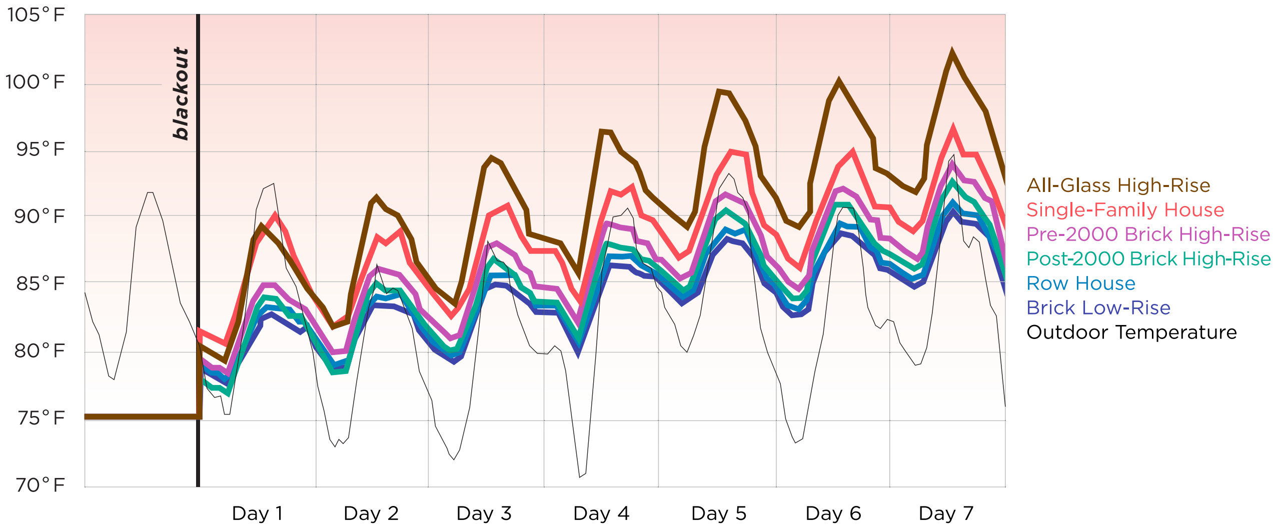
High-Performing Building



At the end of the week, there would be an 18°F to 27°F difference between a typical existing building and a high-performing building of the same type. All the high-performing buildings would maintain temperatures above 54°F.

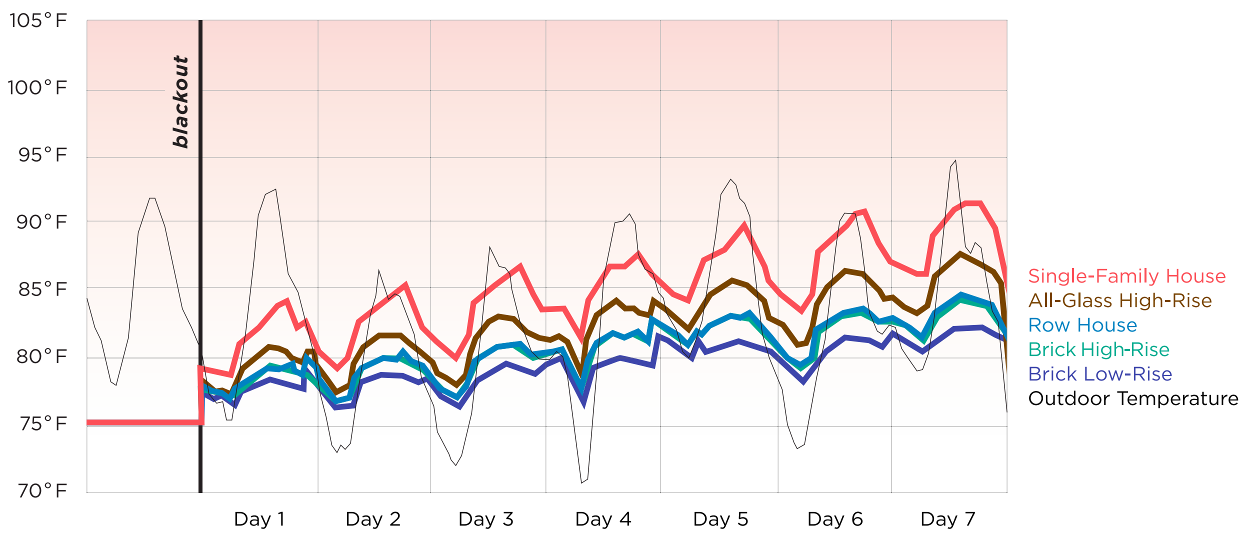
Indoor Temperatures During a Summer Blackout

Typical Building



The typical all-glass high-rise apartment and single-family house heat to almost 90°F on the first day. The all-glass apartment climbs above 95°F on the fourth day and peaks over 100°F. The brick buildings, including the row house, low-rise and high-rise apartments, stay cooler throughout the week but still end above 85°F.

High-Performing Building



High-performing brick buildings, including the row house and brick low- and high-rise apartments, would stay below 80°F for the first half of the week, and never go above 85°F. The high-performing glass building reaches 88°F and the single-family house still rises above 90°F.

ANALYSIS

Within a building category, there are three important factors that influence temperature in buildings during blackouts. These are the type and amount of window area, the amount of air that escapes through cracks and leaks in the walls, and the amount of insulation in the walls and roof. All three factors can be improved during the design and construction of new buildings, and in the renovation of existing ones.

> Glass conducts about five times more heat than a typical insulated wall.

Between two buildings that are otherwise equivalent, the one with more window area will be colder during a winter blackout. Even the extra sun through a well-lit south window will barely make up for the absence of insulation; windows will lower temperature faster than a wall would. During a summer power outage, glass causes the building to heat up more. Daylighting and energy benefits are minimal if windows take up more than 60 percent of wall area.[7]

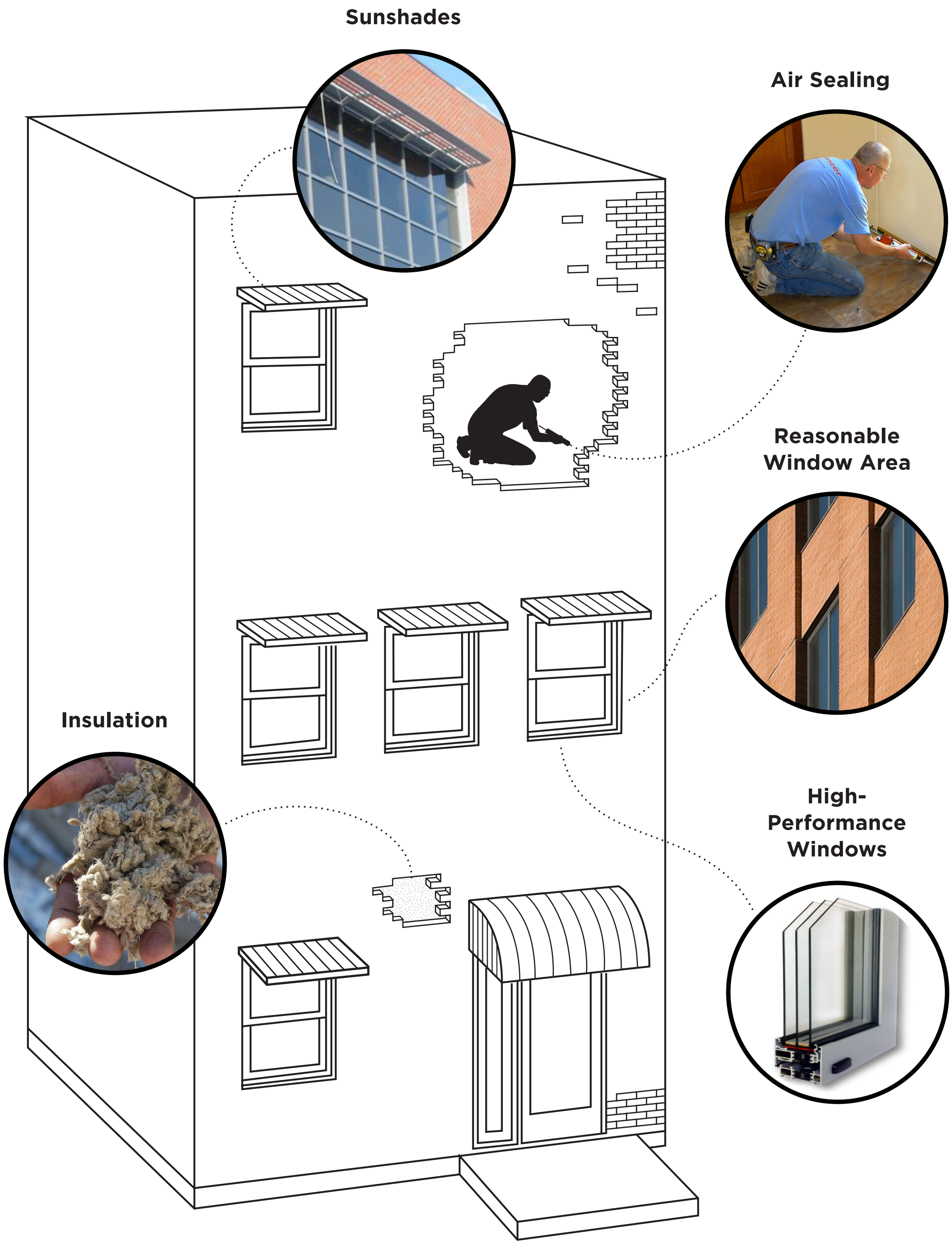
Using triple-paned windows can lower winter heat loss, although glass will never hold heat as well as insulated walls. In summer, any building can stay cooler with windows that are designed to allow in light but reflect heat, as do the windows in our high-performing models. Sunshades can also be added to windows to block the sun in summer but allow the low winter sun in.

Most residential buildings constructed more than five to 10 years ago leak substantial amounts of heated air through cracks and leaks in the walls, windows and doors. Plastic wrap is one common method used to stop this heat loss, which is why buildings under construction are wrapped in bright pink, yellow, or green film. Builders are reducing leakage even further with careful caulking and sealing. Eventually, drafts can be virtually eliminated, with all ventilation intentionally provided by systems that recover heat from the waste air being exhausted from the building. These improvements can also be made to existing buildings.

Adding insulation prevents heat loss through walls and roofs. New buildings can easily accommodate extra insulation, since it is straightforward to add it during construction. In most cases, insulation can be added to older buildings, either indoors or by adding a new exterior layer.

Over time, building codes have improved, meaning newer buildings have better windows, fewer drafts, and more insulation than they used to. But resiliency calls for high-performing buildings that go beyond the current code. These buildings would use advanced practices and materials that are being deployed in the best buildings today. Described in detail in Urban Green Council's "90 by 50" report, they incorporate windows that retain heat in winter and keep it out in summer, rigorous air sealing, and extensive insulation. Since these resiliency measures also save energy, they often pay for themselves, particularly in new construction.[8]

High-Performing Building Practices and Materials



CONCLUSIONS

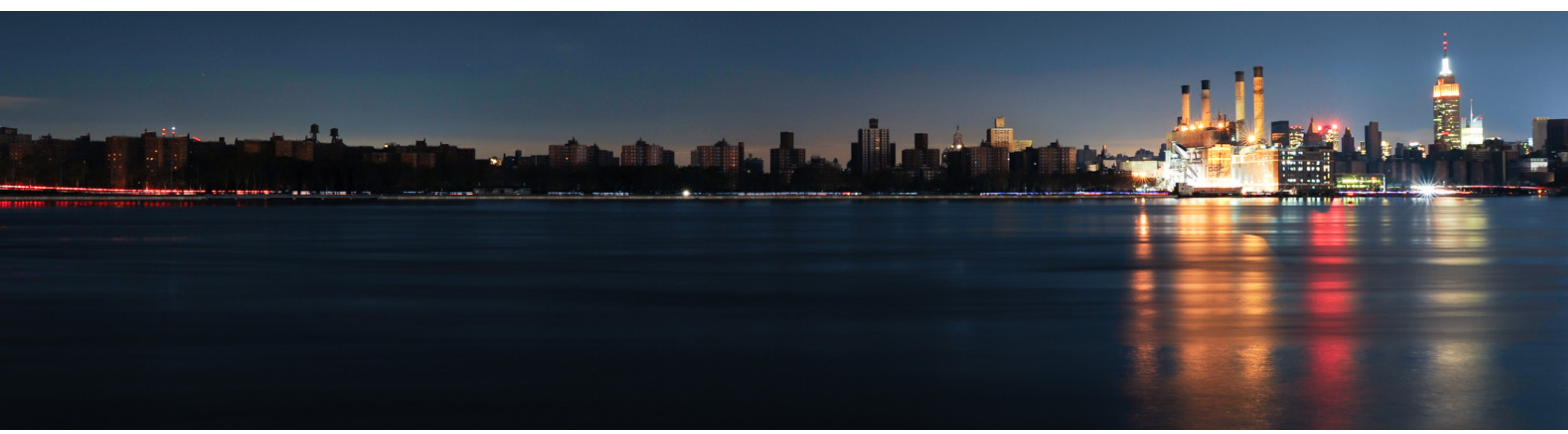
Our city needs more high-performing buildings that could give protection against severe outdoor temperatures for a week or more during a blackout. In winter, temperatures in many New York City buildings would drop below 40°F in three to five days. A summer blackout would send temperatures to 90°F or higher in some buildings on the first day.

One hundred years ago, buildings heated by wood or coal faced cold indoor temperatures if fuel ran out.[9] But they did not depend on electricity to run their heating systems and would not suddenly lose heat all at once. Similarly, buildings with natural ventilation didn't depend on air conditioning and fans. Today's buildings are different, and we face the risk of a power outage causing a widespread, immediate loss of heating or cooling capabilities citywide.

Not all buildings hold their temperature equally well without power. The brick walls of row houses and low- and high-rise apartments hold some heat, and newer buildings tend to be better insulated. On the other hand, single-family houses are exposed on four sides, and all-glass buildings lose heat through their windows in winter and gain it in summer.

High-performing buildings provide the best protection against blackouts during severe weather and would maintain habitable temperatures for an entire week.[10] These new and renovated buildings use readily available construction practices such as installing better windows, adding insulation and eliminating drafts.

Superstorm Sandy taught us that the risk of an extended power outage is real. When harsh weather and a blackout come at the same time, high-performing buildings can help people remain in their homes by maintaining livable indoor temperatures without power. It will take time to prepare cities against disasters. We can start now by building new high-performing buildings and renovating the ones we have. Everyone deserves the protection of a resilient building.



Widespread blackout in lower Manhattan during Superstorm Sandy.

TECHNICAL APPENDIX

Table 1: General Assumptions for Modeled Spaces

Residential Type	Structure	Modeled Unit Area (ft^2)	Room Height (ft)	Exterior Façades (#)	Exterior Façade Area (ft^2)	Glazed Area (%)	Occupancy (persons)
Single-Family House	Wood Framed	676	8	6	967	15	1.6
Row House	Mass Wall	859	8	2	310	30	2.0
Brick Low-Rise	Mass Wall	610	8	1	160	30	1.4
Pre-2000 Brick High-Rise	Mass Wall	599	8	1	252	30	1.4
Post-2000 Brick High-Rise	Mass Wall	599	8	1	252	30	1.4
All-Glass High-Rise	Window Wall	686	8	1	274	70	1.6

Two existing brick high-rise buildings were modeled. One is typical of construction techniques before 2000. The other is typical of a brick high-rise built after 2000, to provide a meaningful comparison to typical all-glass construction during this era.

The single-family house and the row house have both northern and southern exposures. For the other building types, the models represent north-facing apartments in winter and south-facing apartments in summer. Apartments facing another direction would experience different indoor temperatures.

In the winter scenarios, infiltration through leaks in walls, windows, and doors serves as the only supply of fresh air. For the summer scenarios, infiltration was increased slightly to mimic the opening of windows at night.

Table 2: Envelope Properties of Existing NYC Residential Building Stock

Residential Type	Opaque Wall Insulation Value	Fenestration (double-glazed, no coatings)			Infiltration
	R Value*	SHGC*	VLT*	U Value* (Assembly)	ACH*
Single-Family House	8	0.7	80%	0.6	2.8
Row House	3.5	0.7	80%	0.6	0.6
Brick Low-Rise	2.6	0.7	80%	0.6	0.4
Pre-2000 Brick High-Rise	2.8	0.7	80%	0.6	0.6
Post-2000 Brick High-Rise	9.5	0.7	80%	0.6	0.6
All-Glass High-Rise	8.1**	0.7	80%	0.6	0.6

Table 3: Envelope Properties of High-Performing NYC Residential Buildings

Residential Type	Opaque Wall Insulation Value	Fenestration (triple-glazed, low emissivity, selective coatings, sunshades)			Infiltration
	R Value*	SHGC*	VLT*	U Value* (Assembly)	ACH*
Single-Family House	30	0.3	50%	0.2	0.29
Row House	30	0.3	50%	0.2	0.07
Brick Low-Rise	20	0.3	50%	0.2	0.05
Brick High-Rise	20	0.3	50%	0.2	0.08
All-Glass High-Rise	20	0.3	50%	0.2	0.08

* R-value is in hour-ft^2-oF per Btu, SHGC is Solar Heat Gain Coefficient, VLT is Visible Light Transmission, U Value is in Btu per hour-ft^2-°F. ACH is Air Changes per Hour at atmospheric temperature and pressure.
** Includes impact of exposed slab edge.

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pg. 6
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High-Performance Windows: Zola European Windows | www.zolawindows.com

pg. 7
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ENDNOTES

[1] New York City Mayor's Office, "Hurricane Sandy After Action, Report and Recommendations to Mayor Michael R. Bloomberg", May 2013, http://www.nyc.gov/html/recovery/downloads/pdf/sandy_aar_5.2.13.pdf; U.S. Department of Energy, "Hurricane Sandy Situation Report #16", November 5, 2012, http://www.oe.netl.doe.gov/docs/2012_SitRep16_Sandy_11052012_1000AM.pdf.

[2] Urban Green Council, "Building Resiliency Task Force, Report to Mayor Michael R. Bloomberg and Speaker Christine C. Quinn", June 2013, www.urbangreencouncil.org/BuildingResiliency.

[3] Urban Green Council, "90 by 50: New York City Can Reduce Its Carbon Footprint 90% by 2050", February 2013, www.urbangreencouncil.org/90by50.

[4] For winter, we used January 19–26, 2013. This was a cold spell, but not an unusual or extreme one. For summer, we used July 1–7, 2012, when temperatures reached into the 90s for four days. Due to low humidity, that week was not as dangerous as it might have been if the same temperatures were accompanied by higher humidity.

[5] Compared to most existing buildings, current building codes require more insulation and fewer air leaks, so newer buildings will generally maintain indoor temperatures longer than older ones—though not long enough to ride out a Superstorm Sandy-length blackout. To see the results of computer models of buildings constructed to current building code, see our website at http://www.urbangreencouncil.org/BabyItsColdInside.

[6] This study is based on New York City buildings and weather. However, it may be applicable to other cities with similar buildings and temperatures.

[7] Table 1 in the Technical Appendix shows the fraction of the wall that is glass for each apartment in the model. The normal range of window-to-wall ratios is 25 to 50% in high-rise brick buildings. Building Science Insights, "Can Highly Glazed Building Facades Be Green?", September 2008, http://www.buildingscience.com/documents/insights/bsi-006-can-fully-glazed-curtainwalls-be-green.

[8] McKinsey & Company, "Unlocking Energy Efficiency in the U.S. Economy", July 2009, http://www.mckinsey.com/client_service/electric_power_and_natural_gas/latest_thinking/unlocking_energy_efficiency_in_the_us_economy; Deutsche Bank Americas Foundation, "Recognizing the Benefits of Energy Efficiency in Multifamily Underwriting", January 2012, https://www.db.com/usa/content/en/ee_in_multifamily_underwriting.html.

[9] The Cornell Daily Sun, "Blizzard Heightens N.Y. Coal Shortage", 14 December 1917, http://cdsun.library.cornell.edu/cgi-bin/cornell?a=d&d=CDS19171214.2.12, Web 17 January 2014.

[10] Baker, William, "Fuel Poverty and Ill Health—A Review", Centre for Sustainable Energy, Spring 2001, http://www.cse.org.uk/pdf/pub11.pdf; Wilkinson, Paul et al., "Cold Comfort: The Social and Environmental Determinants of Excess Winter Death in England, 1986–1996", Bristol: The Policy Press, esp. Fig 7, http://www.jrf.org.uk/sites/files/jrf/jr101-determinants-winter-deaths.pdf; National Oceanic and Atmospheric Administration, "Heat: A Major Killer", http://www.nws.noaa.gov/os/heat/index.shtml#heatindex.