

BASEMENTS ALMANAC

**NEW CONCEPTS &
TECHNOLOGY FOR
IMPROVING THE SAFETY
AND HABITABILITY OF
BASEMENT APARTMENTS
IN NEW YORK CITY**



**Housing
Innovation
Lab:
Basements**

Citizens Housing & Planning Council

February 2020

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Citizens Housing & Planning Council

Citizens Housing & Planning Council (CHPC) is a non-profit research and education organization focused on housing policy and planning in New York City. Since our founding in 1937, CHPC's mission has been to develop and advance practical public policies to support the housing stock of the city by better understanding New York's most pressing housing and neighborhood needs.

For more than 80 years, CHPC's research and education work has helped to shape public policy to improve the city's housing stock and quality of life in New York City's neighborhoods. A team of expert research staff is led by a diverse board of practitioners in the fields of urban planning, architecture, zoning and land use law, housing finance and development, and community development.

Our work brings clarity to New York City's housing issues by presenting research in relatable and engaging ways. Our agenda is practical and always begins with questions, not answers. It is the data, our analysis, and its relevance to the real world that drive our conclusions.



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INTRODUCTION

This almanac showcases new concepts and technologies for enhancing light, air quality, and fire safety. While it is focused on basement apartments, the ideas it presents have broad applicability for better design in all apartments.

Why Basements?

Basement apartments have always been a critical supplement to the city’s housing stock. They are particularly advantageous because they create new rental units without the cost of acquiring land, rent for less than comparable above-grade units, and provide homeowners with a source of revenue to help pay a mortgage, maintain property, or cover other expenses. Basement apartments offer housing options and financial stability to underserved groups such as new immigrants, elderly residents aging in place, and multi-generational households.

Most of New York City’s basement apartments exist within the informal market, due to the financial and regulatory barriers faced by homeowners wishing to undertake a conversion. Keeping these arrangements under the radar jeopardizes the safety and security of both tenants and homeowners, empowering neither with leasehold rights and allowing the potential for unsafe living conditions. Streamlining a pathway for the conversion of basements into safe, legal apartments would make these housing arrangements safer and more stable, for homeowners and tenants, and add to the housing stock during an affordable housing crisis.

Despite the advantages of basement conversions, the concept remains controversial. The resistance stems in large part from misconceptions about the safety and habitability of the units. Basement apartment skeptics are concerned that proponents want to “loosen regulations”

or “legalize” existing substandard conditions. Yet basement apartments can and should be safe and habitable. CHPC’s 2019 Housing Innovation Lab: Basements event provided a forum to explore and debate ways of improving or enhancing safety and quality of life in basement units, and to rigorously consider whether the current codes are achieving their underlying intent.

Advancing basement conversion policy is difficult because the topic is simultaneously dry, technical, and controversial. It is an issue that requires collaboration between engineers, elected officials, advocates, and government agencies. While highly technical in nature, it is also fundamentally human. CHPC is grateful to its advocate partners at the Basement Apartments Safe for Everyone (BASE) campaign who continue to highlight the urgency of this issue to the well-being of the communities they serve.

Inspired by the ideas presented at the Housing Innovation Lab event and those featured throughout this almanac, CHPC hopes to show that basement apartments can be safe and habitable. Basement apartments can provide a financial cushion for low-income homeowners, a foothold into the NYC housing market for low-income renters, and additional housing supply in an affordable housing crisis. This almanac showcases new concepts and technologies for enhancing light, air quality and fire safety. While it is focused on basement apartments, the new ideas it presents also have broad applicability for better design in above-grade apartments.

CHPC

Basement Initiatives

Over the last several years, CHPC has undertaken a number of research initiatives to understand the physical and regulatory context of basement apartments in New York City. From this research, CHPC has developed a number of policy recommendations that would facilitate the conversion of basements into safe and legal rental apartments. Initiatives have included:

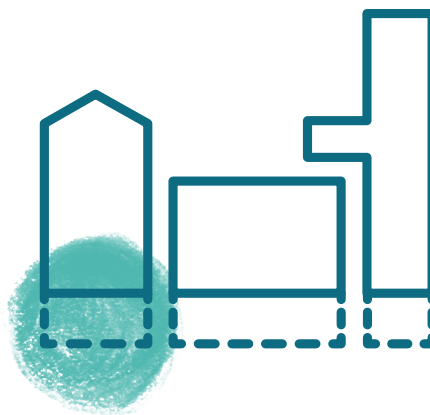
Hidden Housing Report and Maps

Analyzing land use, zoning, and tax data, CHPC calculated the number and distribution of potential basement conversions in New York City. CHPC found between 10,000 and 38,000 basements citywide with the potential for conversion under existing zoning rules. Many additional units could also be converted given regulatory reform allowing for cellar habitation, alleviating parking requirements, or facilitating an additional unit in two-family homes. CHPC aggregated the analysis results into interactive maps, which allow users to explore regions of the city with the greatest number of potential conversions, and to see how their locations coincide with parking requirements, median rents, and foreclosure actions. The findings were also published in CHPC's 2016 *Hidden Housing* report, which put forth recommendations to the City for the creation of a basement conversions pilot program.

Administrative Relief Memo and Regulatory Checklist

These two publications detail the regulatory obstacles—both physical and administrative—confronted by homeowners who pursue basement conversions. CHPC undertook a comprehensive review of all the laws and codes that pertain to basement apartments in one- and two-family homes, itemized those regulations, and assigned each a status based on its difficulty of compliance. The objective of this work was to illuminate how current housing codes and processes make it confusing, onerous, and expensive for a low- or moderate-income homeowner to legally convert their basement.

Explore CHPC's interactive
Hidden Housing maps!
www.hiddenhousingnyc.com



Basement Conversion Assessment Tool

CHPC turned its extensive research findings on administrative and regulatory barriers into an interactive tool that can be used to assess the feasibility of a basement conversion. Users are guided through a series of questions about a particular basement, receiving immediate feedback on potential issues and the overall feasibility of conversion. CHPC's assessment framework formed the basis for the evaluation tool now being used by the City and its partners to select basements in East New York, Brooklyn to participate in the City's ongoing Basement Apartment Conversions Pilot Program.

Housing Innovation Lab: Basements

CHPC conducted research on global best practices and new technology in fire protection, lighting, and ventilation systems that would improve the safety and habitability of basement apartments. In February 2019, CHPC hosted housing policymakers and practitioners at its inaugural Housing Innovation Lab event to showcase highlights of the research. Engineers, researchers, and entrepreneurs were invited to discuss their ideas and technologies and debate with expert jury panels comprised of renowned architects and agency officials, including New York City Council Member Brad Lander and New York City Fire Department Deputy Assistant Chief John Buckheit. This *Housing Innovation Lab: Basements* almanac serves as a reference guide for those interested in exploring the ideas presented at the live event.

Watch the Housing Innovation Lab: Basements event online

chpcny.org/housing-innovation-lab-basements

LIGHT

Performance-based lighting schemes could offer occupants a similar or improved experience relative to the one-size-fits-all prescriptions of the code.

Access to light is essential for a good quality of living. A decent standard of light is one of many standards set by the New York City Building Code to ensure the health and safety of building occupants. Habitable rooms are required to have a minimum glazed area equal to 10% of the size of the room being served, and each window must be at least 12 sf in size. The code further requires that windows be located at a specific height relative to the floor, ceiling, and exterior grade.

While the Building Code includes many dimensional requirements for glazing, it does not ensure that a home receives a specific amount or quality of light. For example, a window that meets the dimensional requirements of the code is permissible, even if it faces out on an alley and provides the room with little or no direct sunlight. Frosted glass transmits less light into a room than clear glass, yet a window of either type is equally acceptable, so long as it is sized and placed correctly.

In basement apartments, the window requirements of the code are often difficult and expensive, or even impossible to meet. This unnecessarily limits the supply of affordable housing that can be created through basement apartment conversions. There are many performance-based lighting schemes that could provide an alternative and complementary path to

code-compliance, offer occupants a similar or improved experience relative to the current code requirements, and ensure that rigorous health and safety standards are met.

The visual transmittance of light is influenced not only by a window's size and position, but also by its tint, frits, coatings, laminations, and grille pattern. The design and finishes of a room also directly impact how light is experienced within it. Partition walls can be optimally oriented and painted to reflect and distribute light into the space. Daylight redirection devices like louvers, heliostats, or light shelves can allow daylight to penetrate deeper into the room. Daylight-responsive controls can adjust the amount of electric light needed to supplement natural light, reducing electricity demand. High-quality electric lights that provide the same benefits as a daylit room can complement windows and increase overall light levels.

Basement spaces often have limited access to daylight and require thoughtful solutions to bring in more light. Provided that egress and ventilation are accounted for, innovative, performance-based approaches to lighting could offer a more flexible way of meeting the intent of the building code, while improving the quality and consistency of residential lighting.

Lighting Explainer

The following content is adapted from Star Davis' presentation at CHPC's Housing Innovation Lab: Basements event. Ms. Davis is the Head of Lighting Design at WeWork.

Lighting is a highly specialized field involving plenty of technical language. This section defines some of the key terms used by lighting experts to describe amount and quality of light, along with industry-established best practices for daylighting.

Key Terms + Metrics

Lumens

describe the **total quantity of visible light** emitted from a light source.



Street Light

6,000 – 10,000 lumens



4' Fluorescent (ceiling panel)

3,000 lumens



Decorative Lamps

50 – 400 lumens



Candle

10 lumens

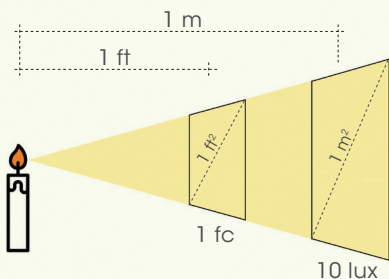
Wattage describes the rate of electricity used by a light source. For example, a 40 Watt incandescent lightbulb uses 40 Watts of power to give off 450 lumens of light, and a 40 Watt LED provides ~4000 lumens of light.

Illuminance measures the **total quantity of light falling on a surface.**

Units of Measurement:

Lux 1 lumen / sq. meter (Metric)

Footcandle (fc)..... 1 lumen / sq. foot (Imperial)



On a bright sunny day, there are about **10,000 fc** on the ground.



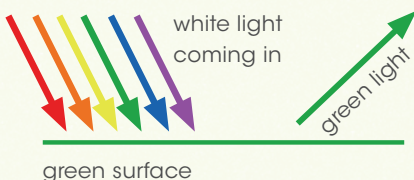
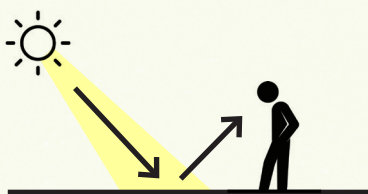
The ground on an overcast day has about **1,000 fc** on it.



On a starry night, as little as **0.1 fc** may be on the ground.

Depending on weather and time of day, the amount of light outside varies greatly. Our eyes can perceive images and objects in a vast range of light levels, and we do not need that much light to achieve daily activities. Indoors, we can accomplish most tasks with only **0.2%** of the amount of light present outdoors on a bright sunny day or **2%** of outdoor light on a cloudy day. This level of illuminance is called “usable daylight.”

Luminance describes the **quantity of light bouncing off of a surface** and back to your eye.



Illuminance is a simpler metric to measure, but **luminance is far more representative of what we perceive.** Depending on its luminance, the same amount of light (i.e. the same number of lumens, lux, or footcandles) may appear much brighter or darker.

Luminance accounts for **material reflectance**—or the color of the surface receiving light. More saturated colors absorb more light and reflect fewer wavelengths back. For this reason, a room with white walls would feel much brighter than a room with dark walls lit by the same amount of light.

Color Temperature

is a **characteristic of light sources** measured on the kelvin scale. It describes how the light emitted from a source looks and feels.



Warmer color temperatures feel cozier and are ideal for living rooms and more intimate spaces. Cooler temperature sources provide more vibrant light and are often used in office and commercial environments.

Reflectance

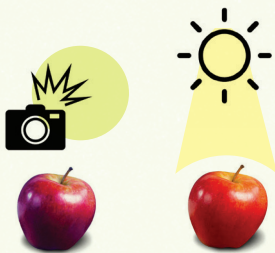
expresses the **percentage of visible light that is reflected by a surface (as opposed to absorbed)**. Reflectance of white walls is ~85%, while for grey/black walls it is ~2-10%.

Finish

describes how **light comes off of a surface**... is it specular (shiny)? Or Lambertian (matte)?

Color Rendering / Color Fidelity

indicates the accuracy with which a light source **reveals the true colors of an object**.

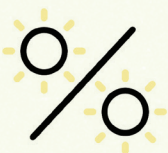


Daylight has a **continuous color spectrum**, meaning that it renders all the colors. Light sources with a more limited spectrum—typically including electric sources—distort the true colors of objects, making them appear different. New technologies are working to achieve the optimal color rendering of daylight with electric light.

◀ *The coloring of an object will appear differently if lit by a light source with a different color spectrum.*

First Principles of Lighting Design

Good lighting design considers the needs of the building occupants and the nature of the space. The light provided should enhance experience of the space, facilitate navigation, allow occupants to perform tasks comfortably, and do so sustainably.



Probability of Sunshine

The likelihood that a location will experience sunshine on any given day depends on location and weather. While the probability of sunshine is fixed by the location, it should be considered in the design. New York City has about a 50% chance of sunlight on any day.



Location + Orientation

The location and orientation of a window will vary by site. Designers have limited ability to control the location and orientation, but both factors must be considered when developing a lighting strategy.

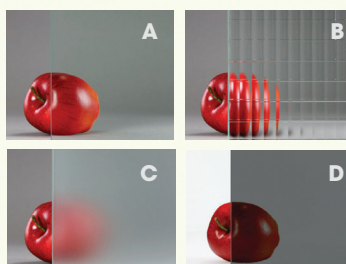
▲ *The house shown has two windows, one oriented to receive direct sunlight and the other in the shade. In the Northern Hemisphere, north facing glazing receives very little direct sunlight.*

Glazing Aperture + Type

An aperture is the opening in a window that allows light to pass through. Glazing type refers to the type of material that fills the aperture.

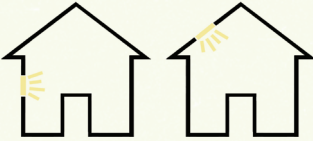


▲ *Le Corbusier's Notre Dame du Haut (1950) has apertures of varying sizes. The finish of the surface around the windows diffusely reflects the light.*



A Clear glass;
B Fluted laminated glass;
C Etched glass;
D Laminated glass with a colored interlayer

Top Light v. Side Light



The New York City Building Code allows one- and two-family homes to substitute skylights (top light) for windows (side light), provided that the same dimensional requirements are met.

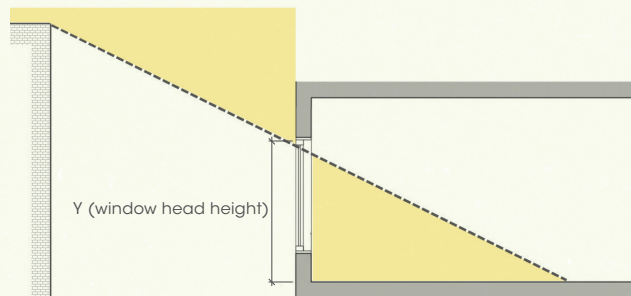
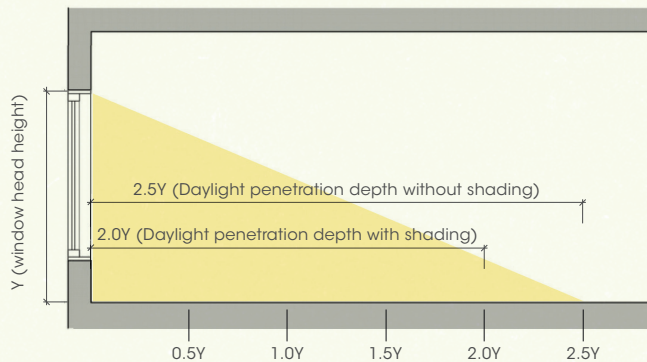
Window Height v. Room Depth

Available daylight decreases as the distance from a window increases. As a good first principle, a window will provide usable daylight over a distance of 2.5 times the window height into the room, absent obstructions.

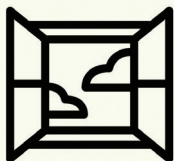


▲ *Partially obstructed view from an NYC window*

- ▶ *Height-to-depth analysis*
- ▶ *Sky view analysis*

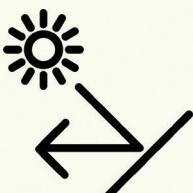


When obstructions are present, the direct line of view to the sky is the best predictor of usable daylight. A sky view analysis looks at the deepest point in the room from which you can draw a direct line to the sky. The zone below that imaginary line will have adequate usable daylight.



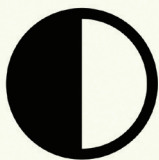
Sky View

Beyond providing useful daylight, a view of the sky gives occupants a connection to the environment, which may have psychological benefits.



Material Reflectances

Reflection off of room surfaces significantly improves light performance. The National Institute of Building Science's *Whole Building Design Guide* recommends keeping reflectances above 80% for ceilings, 50% for walls, and 20% for floors.



Contrast

Providing some variety in brightness levels will improve visual comfort and productivity. As a wayfinding method, injecting bright beams of light into a space can be a helpful way to guide occupants around public spaces, since people are visually attracted to bright areas. Conversely, a lack of contrast tends to be tiring and to reduce attention levels.



To see this innovation presented at the *Housing Innovation Lab: Basements* event, visit chpcny.org/housing-innovation-lab-basements

Rensselaer Polytechnic Institute (RPI) Lighting Study

RPI's Lighting Research Center was tasked by CHPC to analyze a hypothetical basement apartment and assess the performance of eight lighting schemes employing daylight, electric light, or a combination of the two.

This analysis demonstrates how various lighting schemes would impact the habitability of a New York City basement apartment and shows that code compliant solutions do not necessarily provide the most light or the best occupant experience.

The New York City Building Code requires that habitable rooms have a window at least 12 sf in size and a net glazed area equal to at least 10% of the room's floor area. These requirements define the minimum dimensions of the windows serving a room, but does not stipulate the light level that they must provide. In fact, the code offers an exception allowing that "transparent or translucent panels, or other light-transmitting media, may be substituted for window openings" in a one- or two-family home, provided that the size requirement is met (2014 New York City Building Code §1205.2). For example, glass blocks, and fritted, frosted, or tinted panels would be permissible in lieu of traditional

clear glass in these homes. This exception can have an equal, if not greater, impact on interior light level, making the mandatory window size incidental.

RPI's analysis simulates how a number of factors in addition to window size influence the amount and quality of light experienced in a modest bedroom. Factors studied include window size, light source placement, type of light, wall finishes, glass type, and exterior adjacent space.

All of the lighting simulations were performed using the following set of assumptions, enabling a direct comparison of the outcomes:

- A 13'-0" x 9'-2" (119 sf) bedroom with a closet;
- Typical December 21 (solstice) sun angle for New York City at noon;
- Clear skies, for maximum potential sun ingress;
- Southern exposure of any windows;
- Neighboring fence 10'-6" from the south and 6'-6" in height; the neighboring house 26'-0" in height;
- Calculations performed using Lighting Analysts AGi32, version 19.3;
- Consistent image exposure of 1.0.

Scheme A, or the “Base Case” scenario, assumes a typical 40” x 66” window providing the requisite 12 sf of “daylight opening,” so that the room is code-compliant. It also assumes:

Window: Equivalent of Andersen DHG3456 with untreated glass

Reflectances: Ceiling 80%, walls 50%, floor 20%, light well 24%, yard 42%, exterior fence 23%, exterior neighbor’s house 50%

Scheme B is a replica of Scheme A, except the 12 sf window is made of frosted glass instead of clear glass. This scheme also meets the requirements of the New York City Building Code.

In **Scheme C**, the base case scenario is modified to be entirely below-grade, and the window size is governed by egress requirements. Instead of the 12 sf window present in Schemes A and B, Scheme C contains a single egress window with a reflective light well, a product which bounces light up onto the ceiling and into the room. Although reflective light wells are not currently available in the U.S., they are available in the U.K. Scheme C would not meet the code’s dimensional requirements for natural light.

Scheme D modifies Scheme C by removing the reflective light well from the egress window and adding an electric lighting solution to complement the available daylight in the room. In Scheme D, electric lighting for circadian entrainment is produced by wall-mounted, flat luminaire panels near the desk.









Scheme E modifies Scheme C by adding a second egress window and reflective light well to the eastern wall of the room.

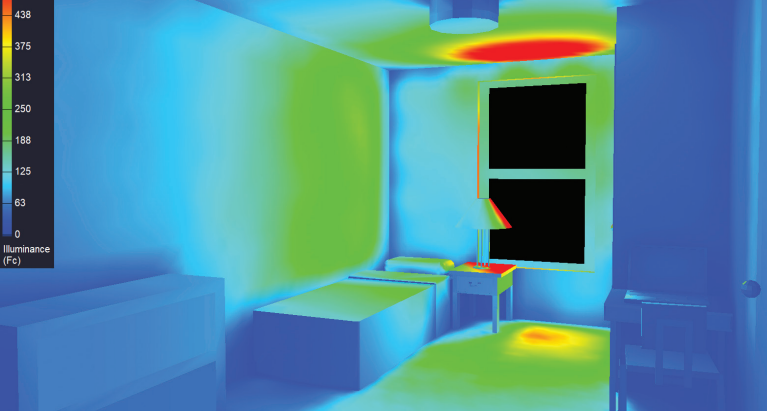
In **Scheme F**, the room again contains a single below-grade egress window, akin to Scheme C, but without a light well. The available daylight is complemented by an artificial window comprised of three flat luminaire panels.

Scheme G modifies Base Case A by changing the surfaces inside the room to dark finishes, altering the scenario’s reflectances.

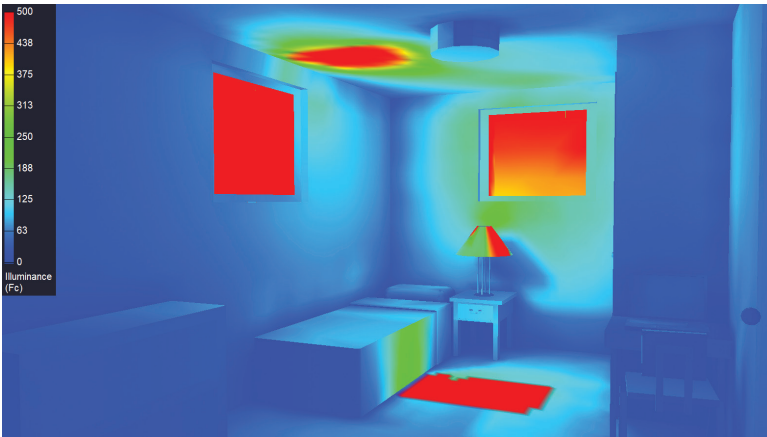
Scheme H again duplicates Base Case A, but adds an artificial skylight to the ceiling in the center of the room.

For each simulation, the average illuminance (F_c) in the room at 30” above the finished floor was measured as a standard of comparison for lighting performance between schemes. The following table illustrates this comparison and summarizes the changes in performance between schemes.

Scheme	Average Illuminance (Fc) 30" above floor	Performance Summary
A Base Case	428 	Light is concentrated in a patch on the floor; not much is on important surfaces like the bed and desk.
B Base Case w/ frosted glass	182 	Least light overall, yet light is more uniformly distributed around the bedroom than in Base Case A.
C Single egress + light well	277 	More light than Base Case B, yet light is concentrated in a patch on the floor.
D Single egress + circadian electric	319 	Over 200 fc at eye level when working at the desk (only 40 fc of white light at the eye is needed for circadian solution).
E Double egress + light wells	337 	Light distribution is more balanced throughout the room; daylight penetrates deeper into room.
F Single egress + artificial window	475 	Highest average illuminance of all schemes, providing 50 fc at the back of the room - more than is typically needed in a residential bedroom.
G Base Case A w/dark finishes	401 	Dark surfaces absorb some of the light, so slightly less light interreflects overall.
H Base Case A + artificial skylight	296 	The skylight brings diffuse light throughout the room.



◀ The frosted glass of Scheme B emits half the light of clear glass; half is reflected back to the exterior, while the other half is partly redirected up, down, and sideways, rather than continuing directly downward. While Scheme B meets the code requirements, it provides less illuminance than Scheme E.



◀ The two egress-sized windows of Scheme E do not meet code requirements but allow daylight to penetrate deeper into the room.

Scheme G ▶ illustrates the impact of dark interior finishes on the appearance of light in a room. Dark surfaces absorb some of the light, so that slightly less light interreflects overall relative to Scheme A.▶





To see this innovation presented at the *Housing Innovation Lab: Basements* event, visit chpcny.org/housing-innovation-lab-basements

Photometric Comparison

The light levels shown in these simulations are on average very high and greater than is necessary for typical visual tasks. Scheme B provides the least illuminance at an average of 182 fc, which is still significantly higher than recommended minimums (5 fc generally; 20-40 fc in reading and task areas). However, a change in time of day, season, and weather would impact the lighting outcomes of any of the schemes.

Though it provides the least illuminance, Scheme B is compliant with the New York City Building Code. Other schemes including supplementary electric light are noncompliant, despite providing significantly higher illuminance than Scheme B (in some cases, even double the amount).

The way that light is diffused throughout a room or concentrated within specific areas is also an important consideration. Schemes A and C provide less light around the bed and desk area, although they provide higher levels of illuminance than Scheme B, in which light is more uniformly distributed. In every scenario, there is a strong patch of sunlight near the window and lower light levels throughout the rest of the room. Important surfaces that need light (the bed, dresser, and desk) have relatively low light levels when primarily lit by one window.

Discussion

Windows can provide very high light levels which can be sufficient for circadian stimulation. They also have benefits beyond illumination, including a view to nature, ventilation, and space for air-conditioners. On the other hand, windows have some disadvantages as compared to electric lighting: they can cause glare and loss of privacy, transmit sounds that disturb sleep, contribute to undesirable heat loss or gain, or allow moisture ingress—especially in a basement. Electric lighting can be used to achieve a higher level of illumination than is provided for by windows alone in residences of all sorts. If illumination is the main concern in basement apartments, where there may be less physical space for glazing than in above-grade homes, electric lighting can be a cost-effective and attractive solution to supplement the amount of daylight present.



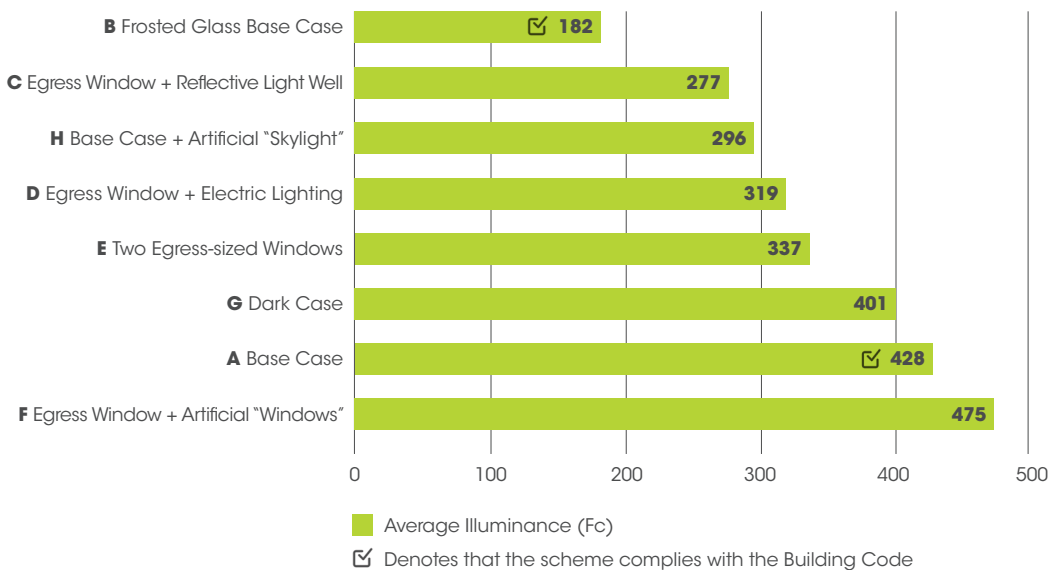
About The Lighting Research Center

The Lighting Research Center (LRC) at RPI is the world's leading center for lighting research and education. Established in 1988 by the New York State Energy Research and Development Authority (NYSERDA), the LRC conducts research and education and works with partners worldwide to develop innovative lighting solutions.

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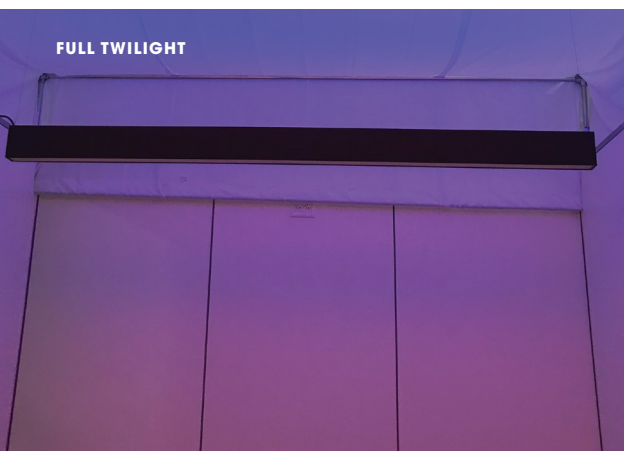
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COMPARISON
Average Illuminance (Fc) at 30" Height Above Floor



◀ The two windows in Scheme E (shown at left) are sized to meet egress and ventilation requirements. Together, the windows provide the net glazed area that is required to serve the room. Yet neither window meets the dimensional requirement for each glazed area to be at least 12 sf. Scheme B satisfies both requirements and is code-compliant, even though it provides a lower average illuminance than Scheme E (see chart above), which is not permitted by the code.

BIOS Human Lighting



The Importance of the Circadian Rhythm

Our circadian rhythms are driven by the “biological clocks” present in every single human cell. These rhythms, which are synchronized by natural sunlight, signal to our bodies when we should sleep and when we should wake. Certain wavelengths of sunlight communicate directly with our biology to achieve this aim. This process is wired deep in human DNA and has resulted from millions of years of evolution, most of which we spent outdoors without electric light.

Today, most people live and work under electric light, and our sleep and health are suffering as a result. The cumulative effect is often referred to as “social jet lag.” In the short term, social jet lag results in exhaustion and stress. Yet over time, it can lead to more serious health issues, including increased risk of heart disease, metabolic disease, obesity, diabetes, depression, and even ADHD in children.

Shining a New Light on Public Wellness

With new research and data on circadian biology emerging every day, one thing is clear: our health is largely dependent on a healthy circadian rhythm. It is common knowledge that better sleep results in better health, but sleep patterns are not the only functions regulated by circadian rhythms. They can influence hormone release, eating habits and digestion, body temperature, and a host of other bodily functions that are crucial to human health.

Scientific research has clearly shown that too much time under electric light is damaging to our health. Of course, society will not be moving back towards outdoor living anytime soon, yet there is an alternative solution: circadian lighting.

BIOS® develops circadian lighting solutions that bring the benefits of natural light indoors. Utilizing a recently discovered photoreceptor in the human eye, BIOS is able to deliver a specific wavelength of light that communicates directly with, and regulates, certain circadian functions. With applications for use ranging from healthcare facilities, to workspaces, to schools, to housing, this technology has the potential to have a net positive effect on public health and wellness.

Everything in our biology and psychology is affected by access to light. But in modern times, we often lack access to light at the times of day when we need it the most. What if electric lighting could be better than a window at delivering the health benefits of daylight?

The Magic of Twilight

The latest research has shown that not only is the presence of natural light crucial to maintaining circadian balance, but that during certain parts of the day, the light spectrum is as well. Twilight acts as an amplifier for circadian signals, priming our internal clocks and giving our bodies a boost, signaling the important change from day to night. While some windows can provide the opportunity to experience twilight, many of us are not commonly exposed to and do not witness this change during dawn and dusk.

Lack of twilight exposure is an issue across the country, especially in urban areas. People living in densely built cities or in some alternative housing typologies, such as basement apartments, often experience more restricted access to natural light. Even urban dwellings with ample window space can fall short in providing the necessary twilight stimulus to regulate healthy sleep patterns, as shade and shadows are common. Urban density simply does not allow for windows that provide the full spectrum of natural light throughout the day. BIOS®, however, has developed a circadian solution.



Color Separation™: Bringing Twilight Indoors

On the heels of a breakthrough discovery on the critical importance of purple wavelengths of light during twilight hours, BIOS has developed cutting-edge technology to bring the twilight spectrum of light indoors and provide “time of day” cues to the body. BIOS® Color Separation™ technology provides important beginning- and end-of-day twilight signals that help amplify the effects of daytime sky-blue light and reinforce our biological clocks to promote better sleep patterns and better health. This pioneering technology can be retrofitted into almost any lighting fixture and has the potential to spur a monumental shift in how we light homes and apartments in order to improve public health.



To see this innovation presented at the *Housing Innovation Lab: Basements* event, visit chpcny.org/housing-innovation-lab-basements

Ready to Start Using Healthy Indoor Lighting?

BIOS’ breakthrough Color Separation lighting technology is leading a revolution in healthy lighting. To learn more about how you can implement BIOS circadian lighting solutions into homes, apartments and other non-traditional dwellings, contact us today.

About BIOS

BIOS is a team of physicists, biologists, engineers, designers and former NASA scientists dedicated to a “biology first” approach to lighting solutions and the development of lighting technologies to help life thrive.

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Limitless Ltd Light Shaft

Limitless Ltd daylight systems provide the perfect answer for people who live and work in areas that have low or no natural light by comfortably lighting otherwise dim spaces. Usable building area is optimized, property value increases, and energy is saved. Limitless Ltd systems can be incorporated into a building as a retrofit or designed into new buildings.

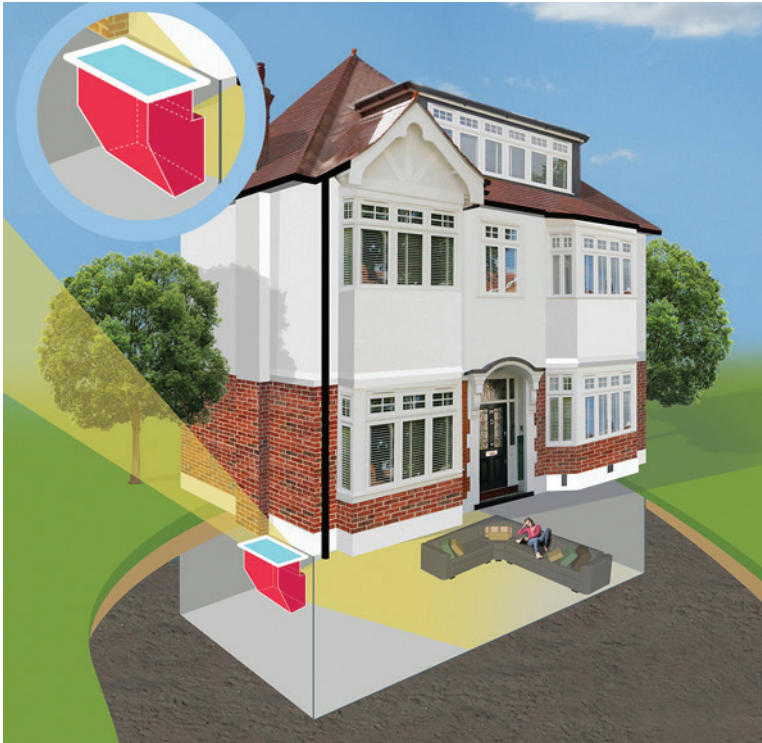
The number of existing buildings in the UK that suffer from inadequate levels of natural light is substantial. Limitless systems have improved daylight within existing homes, historic landmarked buildings, and conservation areas, in addition to newly constructed projects across the UK.

Limitless products have been used to provide daylight for a range of applications, from basements and bathrooms in private homes, to classrooms, theatres, and indoor pools in institutional settings. Private clients have included modest single-family homeowners, performing artists, peers of the realm, and billionaires. Limitless daylight solutions have also been commissioned for numerous non-residential projects for clients including the NHS, Loughborough University, the BBC, London Southbank University, Channel 4, The Home Office, The Co-op, The Priory School, and many private commercial buildings.

Architects, contractors, and homeowners who are familiar with sun tube systems assume that Limitless Light Shafts are similar, though they differ in a number of important ways. Unlike a sun tube, the Limitless Light Shaft improves the distribution of daylight throughout a room. Light is directed to the ceiling, the floor, and horizontally into the depth of the room, filling the entire room with light rather than concentrating it in one small area. Light Shafts can also provide well-regulated ventilation and views to the outside.

Limitless Ltd has developed complementary technologies that can be used as standalone products or in conjunction with its Light Shafts. Walk-On Glass Floors, Ventilated Light Well Covers, and Opening Light Well Covers can be used in combination with the Light Shaft to provide light, ventilation, and egress. The Walk-On Glazing can be designed to accommodate ventilation, a new technique which is currently provided exclusively in the UK by Limitless Ltd.

Known for bespoke solutions, Limitless Ltd designs and fabricates on a project-specific basis. Limitless Ltd tailors each system design to the specific application and context, optimizing efficiency and distribution of daylight. The solution is fully coordinated with the architect, project manager, or builder, who is provided with the relevant scheme drawings and documentation. Installation of all Limitless natural light products is always undertaken by our own specialist team.



The high quality, flexibility, and range of applications of the Limitless solutions make it essential that only Limitless trained personnel install the products.

Unique and inventive systems within buildings require their own unique performance standards indicators. The world's leading building science center, the Building Research Establishment (BRE), has developed and written two suites of software specifically for the Limitless Ltd products. These enable Limitless Ltd to demonstrate compliance with recognized standards to architects, consultants, and end-users. Limitless Ltd assists designers in achieving interior illumination that goes beyond

minimum requirements to “enhance the well-being and satisfaction of people in buildings,” as recommended by BS 8206-2 Code of Practice for Daylight. At a simpler level, the software may be used to provide the end-user with a forecast of the amount of daylight they will benefit from following installation.

Once architects and specifiers discover Limitless systems and put them to use in a project, Limitless Ltd becomes the go-to supplier for all future similar projects. We have become known within our market as experts in natural light solutions.

Light wells and walk-on glazed floors bring natural light into basement spaces, but do not currently count toward meeting the natural light requirements set by the New York City Building Code. If New York City adopted performance-based lighting requirements in place of its current dimensionally prescriptive code, a greater number of units could be developed or brought into the formal housing market, and the City could expect more consistent and useful lighting schemes optimized to suit their specific contexts.

About Limitless Ltd

Limitless Ltd specializes in designing, fabricating, and installing systems that bring daylight into windowless or dark areas in buildings. Our innovative products such as the Basement Light Shaft, Light Well Covers, and Walk-On Glazing, deliver tremendous amounts of light into interior rooms and subgrade spaces, improving utility, occupant comfort, and habitability. Numerous studies have indicated that increased natural light in buildings is a significant driver behind an enhanced sense of well-being.

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▲ *The light shaft behind the window fills a basement office with light and reflects views of the exterior.*

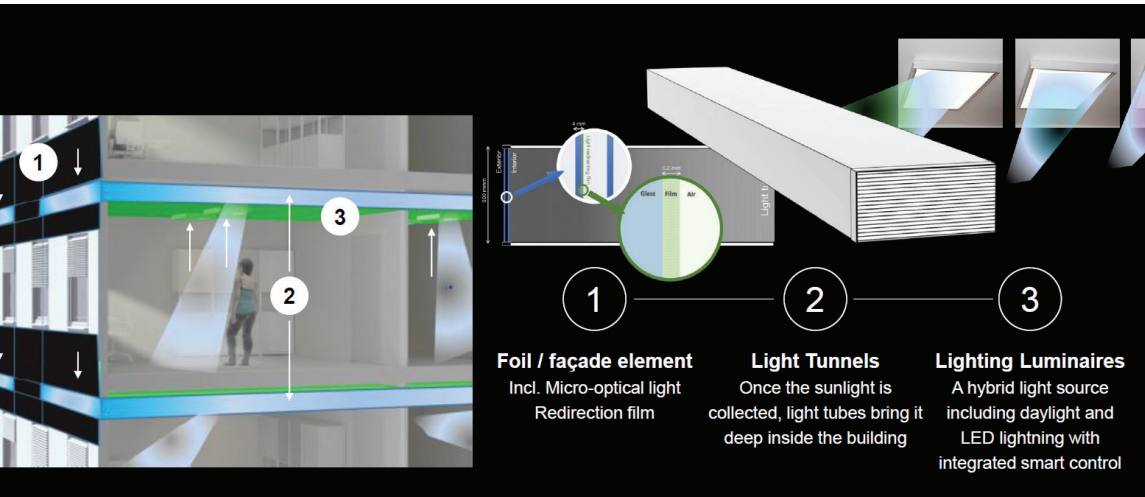


▲ *A Limitless Light Shaft diffuses bright light throughout a basement kitchen.*



To see this innovation presented at the **Housing Innovation Lab: Basements** event, visit chpcny.org/housing-innovation-lab-basements

BASF Skynative



Sunlight through the ceiling 65 feet deep into buildings

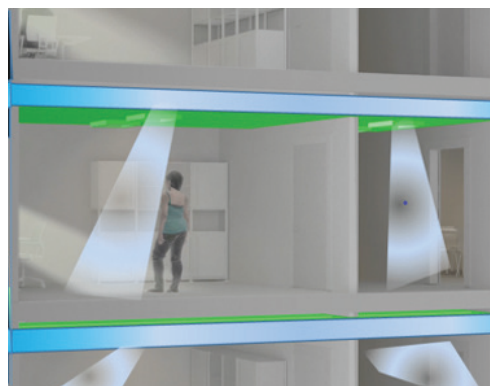
BASF is a German chemical company that has developed and tested a system that brings sunlight up to 65 feet (20 meters) deep into buildings. The system channels daylight through the building facade to lighting “luminaires” that can reach rooms on any building floor, including the basement. Initial testing of a full-sized prototype confirms the results of simulations on the quality and quantity of light coming from the system.

Visitors to the prototype in Innsbruck, Austria report having the same feeling of being “bathed in sunlight” that they experience outdoors, but without the glare. BASF building physicist and daylight expert André Kostro says the system is designed to fulfill the requirements of leading certification agencies focused on green building standards, in particular delivering enough daylight to avoid artificial light during at least 50% of working hours (more than 50% “daylight autonomy”).

The smart system solution is based on the principle of light guidance and is comprised of three components: a foil/façade element, a light tube, and a lighting luminaire. The system can be seamlessly integrated into existing and new facades without limiting design options. BASF is currently testing a hybrid system that combines daylight with advanced LED lighting. The hybrid skylight luminaire is steered by a sensor system, which allows the LED lighting to fade in and out as needed and according to user preferences.

Kostro reports, “When people visit our prototype, they say the perception is unlike any other indoor environment, almost like they are outdoors. They experience the dynamic patterns that sunlight creates as it moves across the sky during the day and how moment-to-moment daylight changes due to clouds, shadows and other conditions outdoors.” The system offers the same health, well-being, and performance benefits as sunlight outdoors. In addition, building owners save between 70% and 80% of the utility cost of typical electric lighting.

Traditional windows do not have to be the only source of daylight. New York’s prescriptive building code does not allow for innovative daylight delivery systems such as Skynative, which could deliver higher-quality light into the depths of a building. Regulating the amount and quality of light, rather than its method of transmission, could liberate new housing stock and improve the habitability of interior space.





Due to its flexibility, Skynative can be used in any type of building and adjusted to building requirements. Skyscrapers, retrofits, underground projects, hospitals, schools, and museums are just a few examples of its broad range of applications. At the same time, the system is modular and easy to install, a key requirement of architects and façade builders.

The BASF daylighting system can be experienced at the 1:1 prototype built with BASF's partner Bartenbach, one of the world's leading lighting research and design companies. In addition to Skynative, BASF is also testing a window film that can increase daylight autonomy to over 50% in offices at depths of around 20-25 feet (6-8 meters), while decreasing the risk of glare and increasing visual comfort.

About BASF Skynative

At BASF, we create chemistry for a sustainable future. We combine economic success with environmental protection and social responsibility. Our portfolio is organized into five segments: Chemicals, Performance Products, Functional Materials & Solutions, Agricultural Solutions and Oil & Gas. Further information is available at www.basf.com.

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Solenica Caia Interior Heliostat

Caia is an innovative and affordable device that can, when provided with a windowsill or other point of access to the building's exterior, fill an entire below-grade studio apartment with natural light. The solution requires no installation and could enhance the habitability of a basement home as soon as it is out of the box.

In fundamental terms, Caia is a heliostat—a mirrored device that continuously reflects sunlight towards a target by rotating synchronously with the sun's movements. Heliostats have been around for some time and are used in applications like daylighting and power generation, although generally on a much larger scale (examples include the PS10 solar-thermal power plant in

Spain and the solar furnace at Odeillo in France). Heliostats as we have known them are typically large, expensive, and require permanent installation, which has made them unsuitable for residential use.

Caia is a small-scale heliostat, created by the designer robotics company Solenica, for use in residential spaces. This natural-light robot illuminates indoor spaces of up to 500 square feet with 10,000 lumens, or the equivalent of 13 lightbulbs. Caia can also send light up to 100 feet away, or one third of the distance spanned by a professional football field.



To use Caia, the user must simply place the device in a location with some access to sunlight, such as a windowsill; choose a target of illumination, like a ceiling or wall; and point the device's main sensor towards the target. Inside Caia, an optical feedback-loop system of interconnected photosensors measures the intensity of sunlight received and then reorients the device's mirror to follow the sun. This process allows Caia to adjust its position throughout the day to keep reflecting sunlight at the user-defined target.

Caia is Wi-Fi enabled, wireless, completely solar-powered, and easy to transport between one's home and office for use in multiple locations. While no installation is required to use Caia, Solenica also offers a Universal Mounting System with wall, balcony, and pole configurations to allow users to position the device for best possible results.

Residents from across New York City, whether they are living in a basement or railroad apartment, could benefit from improved lighting. Many renters lack the resources and authority to retrofit their units with better windows or install more invasive long-term lighting solutions. Small heliostats and luminaires can immediately improve habitability for many apartment dwellers.

About Solenica

Solenica is an Italian designer robotics company that aims to bring the outdoors in, by creating smart, accessible products that leverage the power of the natural elements to transform indoor spaces. With the mission to set a new standard for healthy indoor living, Solenica is in the process of developing a family of smart, data-gathering products, of which Caia is the first. The products will address, in addition to natural light, healthy air, pure water, and food.

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With access to the sun, Caia can brighten an otherwise dark room all day long. Caia can be as effective in brightening a space as 13 lightbulbs.



Sky Factory Luminous SkyCeilings & Virtual Windows



Sky Factory products can be installed in hospitals and other medical facilities to help reduce patient stress and anxiety, as shown above.

Sky Factory is the designer and manufacturer of simulated architectural openings to a “natural” exterior. Their virtual skylights, Luminous SkyCeilings™, and virtual windows, Luminous Virtual Windows™, are designed to simulate a multisensory experience of the outdoors. The images generate a soft, uniform luminescence using calibrated, daylight-quality LED light (6500k). They are intended to create a vivid perceived

connection to open sky from within enclosed spaces lacking daylight and/or a view of nature.

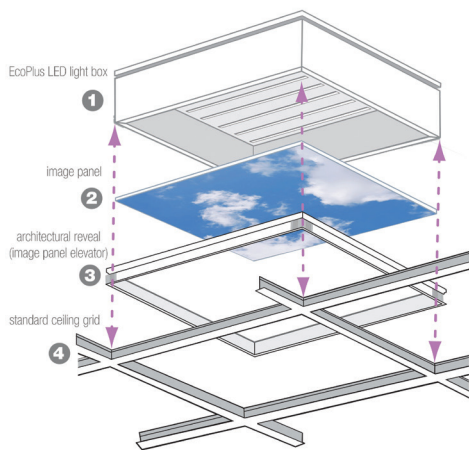
Sky Factory’s virtual skylights and windows contain complex visual compositions. The Luminous SkyCeilings™ begin with images of the sky that are captured at high altitudes and in high-pressure weather conditions, to retain the deep blue color that stimulates circadian cells in the retina.

Many New York City apartments, including basements, lack a good view of the outdoors. Even in high-rise apartments, windows may face the wall of the building next door or a dark mechanical courtyard. Simulated natural exteriors could be used to replicate some of the health and illumination benefits of having a window that connects an occupant to their environment.

The images are then framed, proportioned, and structured in a way that provides visual and spatial cues to the brain's hardwired memory of past experiences of looking up at the sky. The compositional cues engage the brain's ingrained habits of perception so that it interprets the image as an adjoining space (spatial cognition). Sky Factory's Luminous Virtual Windows™ are similarly designed to create an experience of nature.

Sky Factory's products are intended to restore the same health and wellness benefits produced by a true visual connection to nature. These benefits—which include reduced stress and anxiety, recharged cognitive functioning, and more balanced emotions—are above and beyond what can be produced by a back-lit photograph of a natural landscape lacking architectural context. For this reason, Sky Factory's products have been used in settings that prioritize health and well-being, such as hospital rooms, senior living facilities, and educational institutions. According to one study in the *Health Environments Research & Design Journal*, the installation of Luminous SkyCeilings™ above patient beds in a surgical-medical in-patient unit at Covenant Health hospital reduced patients' acute stress by over 50% and their anxiety by over 34%.

Luminous SkyCeiling



 Sky Factory

Open Sky Compositions are depictions of sky events that provide the cognitive benefits of experiencing nature.

Sky Factory's virtual skylights and windows are comprised of slim-profile, modular image panels that allow for surface mounting or recessed, flush installation. Luminous SkyCeilings™ recess the perceived zenith in the ceiling and Luminous Virtual Windows™ recess the perceived horizon line on the walls. These effects make the room around the products feel more spacious and pleasing.

Luminous SkyCeiling™ and Luminous Virtual Window™ panels are available in custom dimensions and with a range of trim styles, including a number of wood options and brushed or powder-coated aluminum, to complement any interior decor.

About Sky Factory

Sky Factory is a small, family-owned company based in Fairfield, Iowa. Sky Factory's design and manufacturing of virtual sky products is a sustainable practice, using 100% renewable energy derived from the company's private, on-site solar installation.

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AIR QUALITY

New technology and best practices in ventilation and bulk water management can help owners and tenants receive the health and wellness benefits of high-quality air inside their homes.

Indoor air quality has a significant impact on the health and wellness of building occupants. According to the National Institute of Health, airborne pollutants can accumulate if not properly addressed, contributing to serious medical conditions including cancer, cardiovascular disease, asthma, and other illnesses. Preventing and treating pollutant sources and ensuring good ventilation are essential to ensuring high-quality indoor air and habitability.

The U.S. Environmental Protection Agency (EPA) ranks biological pollutants, including bacteria, dust mites, pollen, and mold, among the most pervasive indoor air contaminants. Humidity and water exacerbate the growth of these pollutants. According to the Building Science Corporation (BSC), “Moisture problems in existing foundations can be manifested as visible water or puddles, staining of interior (or visible) finishes, mold growth, and efflorescence (water-borne white mineral salt deposits).” Since finishes can hide early signs of dampness, a problem may not be obvious until water intrusion or mold growth is severe.

Bulk water management helps keep a basement dry, preventing the growth of mold and other hazards, and is an essential first step in ensuring good air quality within a home. There are a number of ways to address surface and groundwater including strategically oriented gutters, downspouts, and site grading, as well as reduced permeability, free draining backfill, and a footing drain around the foundation. For more information, see “BA-1015: Bulk Water Control Methods for Foundations,” published in 2011 by BSC.

Good ventilation reduces the concentration of pollutants and allergens in the air, such as volatile organic compounds (VOCs), fumes, dust, and mold, and improves thermal comfort. Ventilation can help control humidity and manage the concentration of pollutants, but it must be coupled with remediation of pollutant sources, whether they are water intrusion, carbon monoxide, radon, gases from combustion equipment, or other sources. Mechanical equipment must be installed correctly and responsibly maintained. Inexpensive alarms can test the air for the most dangerous gases and alert occupants to any problems.

New York City’s codes have few requirements to ensure high-quality air inside one- and two-family homes. Damp-proofing or waterproofing below ground level may be required depending on a home’s location and soil conditions. Habitable spaces must be vented by operable windows or doors opening directly to the outside. The dimensional requirements for operable windows that are mandated by the code may be difficult to meet in some housing typologies, including in basement apartments. Mechanical alternatives that involve ducts, fans, or air exchangers can improve air circulation and quality in a living space. Modern ERV and HRV units can deliver the same high-quality air that is required in newly constructed multi-family buildings. These solutions vary in energy demand and complexity, but new technology has created many energy-efficient options—including entirely passive systems—that could improve air quality in a basement unit far more than a window alone.

Zehnder America ERV / HRV



Heat recovery ventilators (HRVs) or energy recovery ventilation (ERV) systems transfer heat or coolness from stale exhaust air to fresh intake air. These “balanced ventilation systems” introduce fresh outdoor air into a home at the same rate that stale indoor air is exhausted, removing excess moisture, odors, and contaminants while conserving energy and enhancing comfort. An HRV system works continuously to extract moist, stale air from wet rooms (kitchens, bathrooms, and utility rooms) and supply fresh, filtered air to habitable rooms (bedrooms, living rooms, and dining rooms). Up to 90% of the heat in the extract air is recovered by the unit’s heat exchanger and used to heat the incoming air.

The smaller-capacity Zehnder ComfoAir units are ideally suited for small homes and apartments. These decentralized comfort ventilation units perform both heat and humidity recovery using a synchronous supply-and-extract air operation. Their ComfoAir motors perform under all conditions and incorporate a summer bypass to provide cool night air during during hot summer months. ComfoAir units are highly suitable for both retrofit and new build applications.

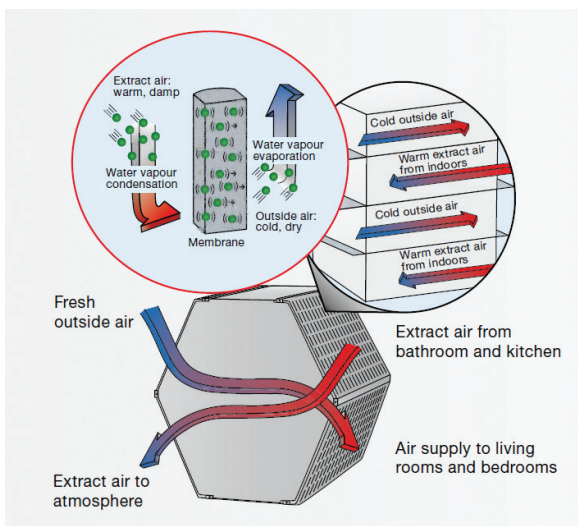
Benefits of an HRV / ERV System

Health: Although the connection between indoor air quality and health issues such as asthma, allergies, and respiratory ailments is common knowledge, the importance of indoor air quality for cognitive

function is less understood. Recent studies of workplaces have demonstrated that indoor air quality affects mood, concentration, and anxiety, and that longer exposure to poor quality air can even lead to personality changes, impaired memory, and slower cognitive function.

Mold is one of the most common threats to indoor air quality. All molds produce allergens and irritants, and some molds also produce potentially toxic mycotoxins. Zehnder systems help prevent mold growth by exhausting excessive moisture that is created by everyday household activities such as showering, cooking, washing dishes, and doing laundry.

The New York City Building Code relies primarily on operable windows (windows that open to the outside) to ensure that one- and two-family homes are properly ventilated. Yet this solution is not always effective. Many New Yorkers leave at least one window closed for months at a time to accommodate window AC units. In some apartments, the only operable window is by a busy street or a garbage bin and lets in odors and car exhaust when opened. Mechanical solutions like ERVs and HRVs can help keep homes properly ventilated when the options for natural ventilation are limited.



Water vapor is condensed out of the moist extract air and is absorbed by a membrane. The moisture and heat recovered are transferred to the fresh air supply with no transfer of odor or microbes.

Zehnder HRV systems are also able to filter out many pollutants from the air before it enters the home. High-MERV filters can stop even small particles—including pollen, bacteria, smoke, smog, and mold spores—from entering. HRV and ERV systems are also designed to exhaust air specifically from bathrooms, kitchens, and utility rooms, where most indoor pollutants originate.

Energy: Most ventilation systems drive up heating and cooling costs, while decreasing indoor comfort. Much like venting a room by opening a window, common ventilation systems can degrade energy performance by exhausting air without capturing heat. Because exhaust fans need supplemental air to operate, they pull in unconditioned air through gaps and cracks in the building exterior, which creates drafts indoors. This has a huge impact on both comfort and energy costs.

HRV and ERV systems conserve energy and lower utility bills. They transfer the heat from exhaust air to incoming air via a heat exchanger. Zehnder heat recovery ventilators are up to 95% efficient, saving energy. This also helps reduce the size of the HVAC equipment that is needed, because it doesn't have to work as hard to heat and cool when the intake air is conditioned by the HRV unit.

Content adapted from John Rockwell's presentation at the Housing Innovation Lab: Basements event and ZehnderAmerica.com.

About Zehnder

Zehnder America Inc. provides high-quality ventilation solutions to promote comfortable, healthy and energy-efficient indoor living. Zehnder America is a division of the Zehnder Group, headquartered in Switzerland. The Zehnder Group is represented worldwide and specializes in advanced heating, cooling, and ventilation technology.

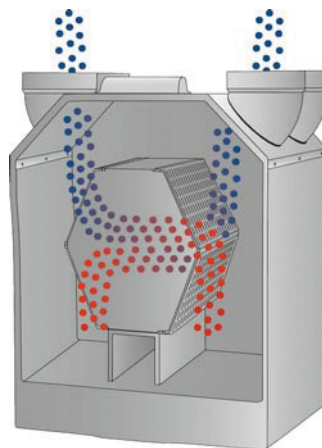
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To see this innovation presented at the Housing Innovation Lab: Basements event, visit chpcny.org/housing-innovation-lab-basements

DELTA[®]-MS Foundation Wrap



Basement apartments need successful strategies to control bulk water around foundations for building durability, indoor air quality, and habitability. According to the Building Science Corporation (BSC), common signs of moisture problems like puddles and stains may not always become obvious until water intrusion or mold growth are severe. In many cases, the application of a dimple membrane can manage ground and surface water appropriately for basement renovations.

DELTA[®]-MS

DELTA[®]-MS is a dimpled membrane that uses exclusive Air-gap Technology to protect foundations from moisture and ensure basements stay dry and last longer.

Long-lasting Moisture Protection, Long-lasting Satisfaction

The vacuum-formed dimpled pattern creates an air gap between the DELTA[®]-MS membrane and a building's foundation, keeping water away from the foundation wall and allowing it to drain. DELTA[®]-MS ensures that basements are permanently dry and protected. Unlike protective sprays, which can crack when concrete walls crack, the DELTA[®]-MS membrane bridges cracks so that no water intrusions can occur. This damp-proofing creates living spaces that are healthier and more comfortable, makes buildings more efficient and durable, and requires fewer warranty claims and costly repairs.

DELTA® Basement Solutions



Foundation

The source of the majority of foundation issues is moisture infiltration. Proper foundation waterproofing will keep the building's structure sound.

Underslab

Protecting the foundation from moisture damage is essential for building longevity. A high-performance vapor retarder and drainage plane will ensure a dry, usable basement.

Floor

Often moisture barriers are only installed on basement walls and not the footings. A reliable capillary break and vapor barrier applied to the floor will ensure full protection.

The Most Durable Dimpled Membrane on the Market

Made from 60% recycled and 40% virgin materials, the co-extrusion process and offset dimples of DELTA®-MS create higher compressive strength and impact resistance, ensuring that its performance and protection last longer, especially when compared to other membranes typically made from 100% recycled materials and sprays.

Whether or not basements are converted into secondary apartments, many homeowners use below-grade spaces for everyday living. Homeowners often locate media rooms, playrooms, laundry and storage, and other regular uses in basements, making it equally important to manage moisture and air quality within them.

Product Benefits

- Impermeable to water and water vapor, keeping basements dry
- Meets all building code requirements in the USA and Canada
- Two lines of defense against water intrusion: dimpled membrane provides capillary break; air-gap allows incidental water to freely drain by gravity
- Eliminates interior dampness and musty odors
- Reliably bridges foundation cracks and deflects soil moisture, unlike asphaltic sprays
- Continues to function even if foundation shifts or cracks
- No unpleasant chemical odors or harmful VOCs
- Resists damage from backfill, like rocks and debris
- Installs in all types of weather

About Dörken Systems Inc.

Dörken delivers innovative, high-performance air and moisture barriers for commercial and residential construction sold under the DELTA® brand name. A North American manufacturer based out of Beamsville, Ontario, Dörken Systems Inc. is a subsidiary of Ewald Dörken AG, a leading European developer and manufacturer of waterproofing and drainage products sold worldwide. Dörken is known for delivering premium products, educational programs, and full technical support.



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Airthings Wave Plus

Airthings is a Norwegian tech company that develops and manufactures products that change the way people monitor and analyze radon and other dangerous indoor air pollutants. Airthings is on a mission to ensure that families, schools and businesses around the world can take control of their indoor air quality (IAQ) through affordable, accurate and easy-to-understand solutions, including its flagship device, the Airthings Wave Plus.

Wave Plus is the first battery-operated, smart IAQ monitor with radon detection. Typical home radon testing kits are expensive, slow-developing, and inaccurate. The Wave Plus solves this issue by offering users short- and long-term tracking of six critical IAQ factors, including three commonly found air pollutants: radon, total volatile organic compounds (VOCs), and carbon dioxide (CO₂); as well as temperature, humidity and air pressure. Each sensor measures levels against a threshold that provides instant, color-coded readings to alert users when a level is too high or too low.

Airthings Wave Plus is the perfect solution for monitoring IAQ in all populated indoor spaces, a necessary practice for minimizing the potential for detrimental health effects and illnesses caused by air pollutants that are often present due to everyday household items or activities. With the versatility to measure air quality

levels in any home, office, school, multi-unit dwelling, or public space, Wave Plus can play an instrumental role in making an abstract concept (air quality) simple to understand, and increase overall health, energy, and productivity.

Because air quality in any indoor environment can have a significant impact on health, Wave Plus provides significant value in both business and personal settings. By monitoring IAQ, building managers can optimize ventilation to save money on utility and HVAC costs; landlords can maintain and increase property value with assurance that they are safely housing their tenants; employers can improve workplace IAQ to enhance the performance, health and happiness of workers; and homeowners can benefit from better sleep, more energy, and improved overall health. Wave Plus is a worthwhile, smart consumer investment and a small price to pay for the substantial financial and health savings it can potentially return to users over time.

The goal of Wave Plus is to empower people everywhere to take control of their environments and achieve peace-of-mind about the quality of the air they breathe. Wave Plus' data collection, alerts, and analytics enable users to minimize their exposure to indoor air hazards, optimize ventilation, and reduce energy costs.



Just as carbon monoxide detectors have become commonplace and mandated by code, radon detectors should be a common feature of habitable basement spaces. Radon is similarly important to detect and, with the aid of new technology, easy to monitor. Areas of the country with elevated levels of naturally occurring radon have even more incentive to integrate radon monitors into residential spaces. To check local radon levels in New York, see the New York State Department of Health Radon Monitoring Program here: <https://www.wadsworth.org/programs/ehs/nuclear-chem/radon>

In addition to its clear health benefits, Wave Plus offers a source of valuable analysis and personalized data to consumers seeking more advanced knowledge about and insights into the quality of the air they breathe. By connecting the Wave Plus device with the free Airthings mobile app and web dashboard, Wave Plus users can: gain access to their data for view and/or export; analyze IAQ in specific rooms; receive notifications and tips to improve IAQ; compare/contrast IAQ in different locations; and find more opportunities to enhance ventilation and further reduce energy costs.



About Airthings

Established in 2008, Airthings is a Norway-based tech company led by a team of experienced scientists, engineers and technology professionals, with a common goal: to educate on the prevalence of Radon, as well as other indoor air contaminants, and develop accessible technology solutions to help people stay healthy.

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Tracking indoor air quality over time helps a user identify possible pollutant sources corresponding to spikes in levels recorded by the Airthings device. For example, the day TOCs spiked may correspond with the installation of a new rug or change in cleaning product.



Wave Home Solutions

6-stage Air Purifier

The Wave Air Purifier is a high-performance, hospital-grade air purifier that helps keep interior air healthy, clean, and odor free. As air cycles through the purifier, it undergoes six stages of air treatment:

1. Permanent washable pre-filter captures large particulates;
2. H12 class hospital grade HEPA filter removes 99.5% of airborne particulates;
3. Activated carbon filter enhances odor reduction capabilities;
4. TiO2 Catalyst reacts with UV light to further destroy Volatile Organic Compounds;
5. Patented UV-C/UV-V “J” Lamp - two high intensity lamps in one bulb.
 - UV-C attacks the DNA of microorganisms to destroy biological contaminants;
 - UV-V destroys chemicals, smoke, odors, and aerosols;
6. Reflector behind the lamps increases the UV intensity.

The patented “J” lamp utilizes dual Ultraviolet (UV) light wavelengths, specifically UVC (254 nm) and UVV (187 nm), to kill up to 99% of everyday indoor pollutants, including mold, viruses, bacteria, and other biological contaminants as well as chemicals, odors, smoke, and aerosols. The UV lamp and a built-in reflector are mounted to increase surface area and exposure time to the UV wavelengths. This unique design provides superior results that are not achievable in purifiers with a single wavelength UV.



The Wave Air Purifier utilizes Smart Sensing Technology to continually sample and monitor air, and to independently control the unit's operation accordingly. If pollutant levels start to increase, the unit will self-adjust and operate at a higher speed until conditions are favorable. This auto-mode offers the best combination of air cleaning and energy efficiency and can keep the interior air within up to 800 sf of space pure, without requiring user attention.

About Wave Home Solutions

The indoor environment in our home is constantly exposed to elements beyond our control and to negative conditions created by everyday activities and from outdoor pollutants that enter indoors. WAVE Home Solutions is dedicated to solving these problems by developing the most advanced and innovative technologies that will provide the highest performance, yet are also energy efficient and easily integrated into the home. Wave products have been used in used in all types of homes including public housing, subsidized affordable housing, privately operated housing, and military housing.

Tenants have limited control over the maintenance of their buildings and the habits of their neighbors that affect the quality of the air inside their unit. While standalone air purifiers and ventilation units are not a substitute for good building management, they can improve the habitability of individual apartments, and give tenants increased control over their health and the air that they breathe.



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EZ Breathe Ventilation System



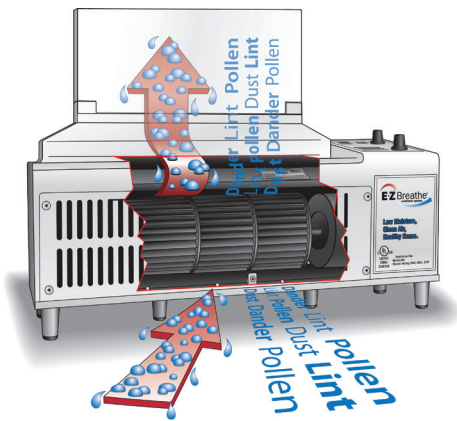
Indoor air quality can be a challenge for any homeowner or tenant. According to the U.S. Environmental Protection Agency (EPA), the air in the average American home is a minimum of five times (and can be as much as 100 times) more polluted than outdoor air. The reasons for this range from the toxins used in home construction, to the type of foundations our homes are built on, and our quest for insulation and energy efficiency. In basement apartments, bulk water management is an essential component of maintaining good air quality. Foundation walls and floors, due to their porous nature, can absorb around 10-15 gallons of water vapor per day—up to 80% of a home's indoor moisture. This vapor accumulates in gaseous form, elevating humidity, which in excess can accelerate the growth of bacteria, mold, and mildew, and attract pests.

The EZ Breathe Foundation Ventilation system significantly improves air quality in basement apartments and the above-grade homes to which they are attached, by getting rid of excessive airborne moisture and common household pollutants. This simple, easy-to-install product uses exhaust ventilation to create fresher, cleaner, and drier indoor environments. Exhaust ventilation is commonly used in many other parts of homes and buildings, such as bathroom, attic, and garage fans and kitchen range hoods. Foundation exhaust ventilation has gained recent popularity nationwide, due to its effectiveness in improving indoor air quality.



EZ Breathe provides a path of escape through which moisture, contaminants, and pollutants are expelled. When placed in the basement, EZ Breathe exhausts water vapor directly at its source, before it can penetrate throughout the home. This reduces the chance for bacteria, mold, and mildew to develop. The system also increases circulation and air exchanges between the basement and the home's upper levels, replenishing fresh air into the basement and expelling any moisture or pollutants from air upstairs.

The EZ Breathe system has been shown to significantly reduce levels of indoor allergens, humidity levels, trapped gases and pollutants, and airborne chemicals. Independent studies showed an 85% reduction in airborne particles and an 85% reduction in mold spores just 30 days after installing EZ Breathe. The system also helps to regulate the temperature inside a home by increasing the efficiency of existing heating/cooling efforts by providing greater air movement.



Homeowners seeking to convert their basements into apartments can use products like the EZ Breathe to ensure high-quality air in both the new apartment and throughout their homes with less invasive installation requirements.

The free-standing system is easy to install and highly suitable for retrofits. It requires no invasive duct work and should be placed inside the basement mounted on an exterior wall. EZ Breathe is also very low-maintenance. It is governed by a humidistat and fan speed, which, once set at the user's desired levels, automatically maintains the device by cycling it on and off as necessary.

EZ Breathe helps both basements and the above-grade homes they are attached to become healthier, more livable, and more enjoyable spaces.

About EZ Breathe

EZ Breathe is a 2nd generation family-owned and operated business that has been working in homes with basements and crawl spaces for over 35 years. The company began providing waterproofing and sealing of below grade spaces, protecting about 500 foundations a month. Committed to delivering superior results, our team developed the EZ Breathe Ventilation System to address not only moisture, but also the odors and pollutants that our customers were concerned about.

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FIRE SAFETY

This chapter shares ideas to enhance fire safety in basement apartments. When used in lieu of, or in addition to, current code requirements, these products and technologies can help provide simple and cost effective ways to prevent, contain, and slow the spread of fire.

Fire protection in a basement space is an utmost priority. The National Institute of Standards and Technology (NIST) states that a home fire can reach deadly proportions in three minutes or less. According to FEMA statistics, residential fires account for the highest number of fire deaths (73.2%), fire injuries (76.5%), and fire dollar loss (54.7%). Among residential fires, one- and two- family homes account for about 60%. Minimizing the risk of fire must be a top priority of any basement apartment conversion policy. Yet, if our codes are so stringent that it is logistically or financially impossible to comply with them, then our standards may not in fact be making us safer.

To comply with current New York City code, a new basement apartment conversion must be fully sprinkled if the building fronts on a street that is less than 34 feet wide from curb to curb—an expensive and invasive part of a conversion. However, there are new technologies and approaches that could provide equivalent fire protection, yet are more cost-effective and easier to install. For example, flexible cross-linked polyethylene (PEX) piping is a variation on existing fire suppression technology that is much less expensive and easier to use in a retrofit, relative to standard metallic piping. Newer, more water-efficient technologies, like the Plumis Automist system that sprays a fine mist of water from a storage tank (rather than the water line pulled from the street), are gaining traction internationally, but have not been adopted in New York City.

Furthermore, most one- and two-family homes in New York City are not required to have an automatic sprinkler system because they are either exempt as detached structures and townhouses under three stories tall or are grandfathered from the requirement. Even homes that do not have an apartment in the basement may use the space for a family room or other habitable purpose. New technologies could make it both physically and financially possible and desirable to retrofit basement spaces with active fire safety measures even though they are not currently required by law to do so to, thereby making these homes safer than current law requires.

Fire risk can be mitigated by installing active fire suppression systems, like automatic sprinklers, that extinguish a fire. Other systems help to prevent or contain a fire. These solutions may be particularly important in circumstances where there is an immediate need for increased protection or where a less invasive solution is required.

This chapter shares ideas for fire safety measures that can help make basement apartments safer. When used in lieu of, or in addition to, current code requirements, these products and technologies can help provide simple and cost effective ways to prevent, contain, and slow the spread of fire.

Fire Statistics

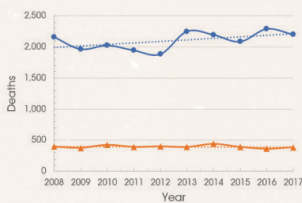
The following content is adapted from David Jacoby's presentation at CHPC's Housing Innovation Lab: Basements event. Mr. Jacoby is a Principal and Leader of the Fire Engineering Practice at Simpson Gumpertz and Heger.

Fire safety is of paramount importance, particularly when it comes to basement apartments. In 2015, FEMA estimated that 6,500 basement fires occur in one- and two-family homes annually. **Basement fires account for 3% of all fires reported in one- and two-family dwellings** and are responsible for roughly 65 deaths, 400 injuries, and \$278 million in property losses each year across the US.

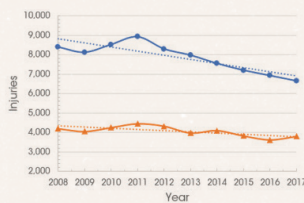
Trends

Fire losses (property damage, injury, and death) are more common in one- and two-family homes than in multifamily dwellings, in large part because the building code requires less stringent fire protection systems within them. Sprinklers, centralized alarm systems, and fire rated egress paths are standard requirements of multi-family construction.

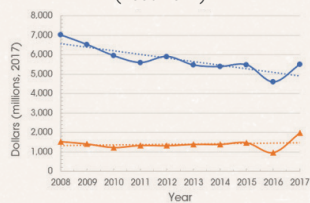
U.S. Residential Fire Deaths (2008-2017)



U.S. Residential Fire Injuries (2008-2017)



U.S. Residential Fire Property Damage (2008-2017)



Source: FEMA and the National Fire Incident Reporting System (NFIRS)

In New York City, most fires occur in multifamily buildings, but that is because most New Yorkers live in multifamily buildings. On a per unit basis, one- and two-family homes experience a greater number of fire incidents.

NYC Fire Incidents (2014-2018)

	 MULTIFAMILY	 1- & 2-FAMILY
Incidents.....	61,336	33,768
Incidents Per 1,000 Units.....	23.8	41.6
Incidents Involving A Basement Or Cellar.....	4,479	3,062
Involving A Basement Or Cellar Per 1,000 Units.....	1.7	3.8

Source: NYC Open Data Incidents Responded to by Fire Companies (2014-2018) Housing and Vacancy Survey and PLUTO 18v1



To see this innovation presented at the *Housing Innovation Lab: Basements* event, visit chpcny.org/housing-innovation-lab-basements



The nationally recognized standards for sprinklers, alarms, and fire protection are published by the the National Fire Protection Association (NFPA). Its codes and standards are overseen by 250 Technical Committees and informed by research and practical experience. NFPA standards are referenced and modified for local use by New York City’s Construction Codes.

Causes

The majority of residential fires begin with cooking, while electrical malfunction and heating system fires were the next most common causes.



Unattended cooking equipment is the leading factor in cooking fires and deaths. Electric ranges are twice as likely to be involved in a fire than gas ranges. Cooking fires peak during Thanksgiving, Christmas, and Super Bowl Sunday.



Electrical malfunctions are the leading cause of basement fires. Hazardous electrical arcing can be produced by damaged wiring, frayed appliance cords, loose connections in wall outlets, and overloaded circuits.



Space heaters were responsible for 44% of home heating fires from 2012-2016, but were responsible for 86% of civilian deaths from heating fires. Heating-related fires peak in January when residents are more likely to use supplemental heaters.

Protection



Sprinklers and smoke detectors reduce the risk of dying in a fire by 82%, yet statistics from the National Fire Incident Reporting System (NFIRS) indicates that few private dwellings are equipped with sufficient protection. Of the one- and two-family homes that experienced a fire between 2013 and 2015, **only 1.2% had an automatic extinguishing system and 38.6% had smoke alarms present.**

First Responder Basement Fire Concerns



- First floor instability
- First responder operations located above the fire
- If the basement apartment is unregulated, it may have an unconventional layout and low ceilings
- Residents tend to store equipment, chemicals, and flammable supplies in basements and cellars.

Plumis Automist



Most one- and two-family homes in New York City are not required to have an automatic sprinkler system, and many homeowners cannot afford to install one. Increasing the number of cost-effective, easily implemented design and product solutions available to homeowners may make basement homes safer than current law requires.

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Intelligent fire protection with no tanks, domestic water feed and much less water damage.

The lifesaving benefits of fire sprinklers are unquestionable; the risk of dying decreases by about 80% when sprinklers are present (Source: NFPA). This is why they are mandatory in an increasing number of residential properties in numerous jurisdictions. That being said, homeowners and developers often cite the following reasons as barriers to adoption: well water supply requirement for a larger tank, min. 1" (+) water supply pipe required, or difficult to retrofit.

Automist Smartscan Hydra is a smarter, modern fire sprinkler system. Instead of the typical ceiling-mounted sprinkler head, this device consists only of a stainless steel panel that seamlessly integrates into the interior of almost any living space. As soon as the system is activated, the head of the unit rotates automatically to directly target fires with a powerful jet of water mist.

The Smartscan Hydra has been proven to achieve the same performance as other similar sprinkler systems. However, one huge advantage it boasts is that this approach uses 90% less water. The result is significantly less water damage to the living space.



To see this innovation presented at the *Housing Innovation Lab: Basements* event, visit chpcny.org/housing-innovation-lab-basements

Why Automist Smartscan Hydra?

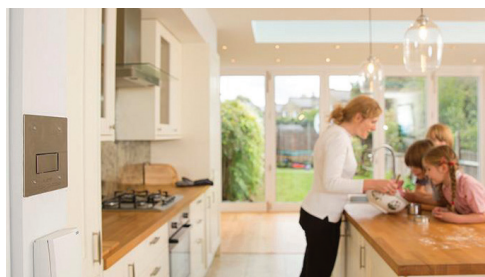
- Direct targeting: Automist® Smartscan Hydra suppresses fires more efficiently by targeting the origin of the fire directly.
- Meets the highest performance standards: Automist® Smartscan has met the fire performance standards outlined in UL 1626/2167 and NFPA 750.
- Low water usage: Automist® Smartscan can be simply installed on a standard domestic water main and doesn't require a plumbing upgrade or a water tank.
- Less disruption: Typically installed in just a few hours with minimal impact to the building, in part due to the use of flexible high pressure hoses.
- Robust activation: Automist® Smartscan Hydra has a robust trigger which uses a combination of smoke, heat, and temperature rate of rise. Therefore, it is not prone to false activations.
- Minimize damage: Automist® Smartscan uses 90% less water than traditional sprinkler systems—minimizing consequential water damage, while providing the same performance.
- Low maintenance: Annual tests of the full system operation from detection to activation are quick and simple—usually taking only a few minutes.
- Chain of accountability: Automist® can only be installed by Accredited Installers who are regularly tested, and audited, ensuring high standards are maintained.

Typical Applications

- Fire sprinkler alternative: Applications cited in the 2015 IBC Section 904.11 and NFPA 750 include Residential Occupancies up to and including Four Stories in Height, One or Two Family Dwellings, and Commercial Light Hazard Occupancies.
- Spray head - 2.2" deep wall box mounted 3.9 - 4.6' from the ground.
- Activation Method: Ceiling mounted multisensor detector triggers scanning infrared pyrometer.
- Suppression: 1.6 gal per minute vertical watermist blade made of droplets less than 100 µm in size.
- Pump: 15" (height) by 10" (length) by 8" (width) and weighs 15.4 pounds connected to a min. 3/4" water supply.
- Electric: Independent electrical circuit that operates at 240V.

About Plumis

Plumis aims to introduce affordable home fire protection into the mainstream and bring active fire protection to homes where it was previously considered cumbersome or impractical. The company was founded in 2008 after its founders' Automist technology was named the international winner of the James Dyson Award for design innovation. More recently, the Automist Smartscan won the Red Dot Product Design Award in 2016.



Plastic Pipe Residential Sprinkler Systems

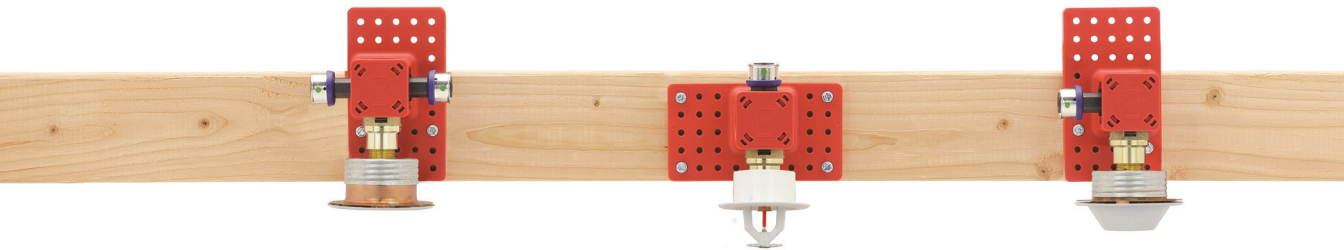
Residential fire sprinklers make it possible to immediately halt fire events and save lives, reduce destruction, lessen demands on responders, and conserve water by extinguishing flames at onset. The Home Fire Sprinkler Coalition (HFSC) shows that fire sprinklers can stop a fire in less than 1 ½ minutes. Sprinklers reduce the chance of death in a fire by over 80%, and in 90% of home fires, a single activated sprinkler head will control the fire.

Piping for residential sprinkler systems can be made from metallic or non-metallic pipe. Non-metallic sprinkler systems are typically constructed using CPVC or PEX piping materials, and deliver significant savings in lives, property damage, and water conservation. CPVC and PEX fire protection piping systems are well-suited for retrofit applications and are proven to provide reliable long-term safety. They meet strict national standards for rigorous performance, are affordable and simple to install, and provide the option to be part of multi-purpose combined systems.

Chlorinated polyvinyl chloride (CPVC) and crosslinked polyethylene (PEX) piping materials have been in commercial production since 1960 and 1972 and have been listed for residential fire sprinkler systems since the 1980s and 1990s, respectively. According to the National Fire Protection Association (NFPA) 13D Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes, to provide an affordable sprinkler system in homes while maintaining a high level of life safety, CPVC and PEX fire sprinkler systems that are listed to system standard UL 1821 Thermoplastic Sprinkler Pipe and Fittings for Fire Protection Service are approved to supply water to fire sprinklers for one- and two-family dwellings. Certain CPVC plastic pipe and fitting systems listed to system standard UL 1821 can be used to supply water to fire sprinklers for low-rise residential occupancies, according to installation standard NFPA 13R, and to supply light hazard occupancies according to NFPA 13. Each approved PEX or CPVC product carries its own listings for specific applications.

The 2014 New York City Building Code references an old edition of NFPA 13D, the national standards for sprinkler installation, that predates the inclusion of PEX as an option for non-metallic sprinkler systems. Why not update our code to enable faster, cheaper, retrofits?





Advantages of CPVC and PEX

As compared with traditional metallic fire protection piping materials, CPVC and PEX systems are more reliable, easier and safer to install, and can deliver cost savings to both contractors and homeowners. This is largely because CPVC and PEX fire protection piping systems are resistant to corrosion, install without use of a flame, and contain less expensive materials.

In some one- and two-family buildings, fire sprinkler piping can be combined with a building's cold-water plumbing system and installed as a multi-purpose combined system. These systems further reduce installation costs by simplifying installation and eliminating numerous hardware components needed in a standalone fire protection system. The flexibility of PEX piping makes it especially advantageous for retrofit projects, where tubing can be bent around obstacles and easily snaked through openings in an existing structure.

In all cases, plastic piping and fitting materials are produced and third-party certified to international consensus product standards. CPVC fire protection pipe is produced, tested and certified to ASTM F442 and fittings are produced, tested and certified to ASTM F437, F438 or F439. PEX tubing is produced, tested and certified to ASTM F876 and fittings are tested and certified to ASTM F877. For fire protection applications, all plastic

materials are also tested and listed to UL 1821. Products used for drinking water (plumbing) applications are also tested and certified to NSF Standard 61. Please visit PPI's website for detailed information on each material, relevant standards, code compliance, and design options for fire protection systems. www.plasticpipe.org/building-construction

About PPI

The Plastics Pipe Institute (PPI) is a 501 C (6) non-profit trade association dedicated to the advocacy and advancement of plastic piping systems which are economical and sustainable solutions that benefit society. PPI focuses on research, education, technical expertise and advocacy. Based in Dallas, TX, PPI has over 160 member firms from across North America. PPI's Building & Construction Division focuses on pressure piping systems used in plumbing, fire protection and mechanical applications.

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Pioneering Tech Smart Burners



Cooking fires can be devastating and very costly. They cause over \$1 billion in direct property damage and nearly \$7 billion in indirect costs every year. According to the National Fire Protection Association (NFPA), cooking fires are also the leading cause of fire-related injury and the second leading cause of fire-related deaths. We are all at some risk, although very young children, college or university students, and seniors are among those at the most risk. From 2009 to 2013, cooking equipment was involved in 66% of nursing home fires in the United States. Meanwhile, 6 of every 7 fires in college dormitories start from cooking, and the number of reported incidents has increased 23% since 2003.

At Pioneering Technology, we believe that prevention is the best way to protect loved ones and property from the risk of cooking fires. As North America's leader in cooking fire prevention technologies and products, our mission is to help protect people and property from the leading cause of home fires. Cooking fire prevention is far more effective than fire suppression or detection. Suppression or detection products only react to a fire after it has occurred. We design products that are focused on helping to stop fires from happening in the first place. Prevention also helps avoid the high costs associated with building evacuations, nuisance alarms, smoke damage and even water damage.

The SmartBurner is one of our innovative, high-tech solutions for cooking fire prevention. It is designed for easy installation by replacing the coil elements on electric coil stoves. Using patented, temperature-limiting control technology, the SmartBurner helps prevent fires by limiting the high-end temperature of the burner. Traditional and older electric coils reach red hot temperatures that are better suited to welding than cooking. The SmartBurner avoids those excessive temperatures while still allowing users to cook their food effectively.

Pioneering Technology has installed SmartBurners in over 300,000 kitchens across North America without a single reported cooking fire. While no product can substitute for smart cooking behaviors when it comes to reducing risk, the SmartBurner poses a simple and immediate way to reduce the risk of cooking fire in a basement apartment without any invasive installation. Pioneering Technology's associated products include proven solutions for electric glass-top stoves and microwave ovens.

In homes without fire suppression systems, preventative measures that reduce the likelihood of a fire can provide significant peace of mind. In circumstances where a basement unit is already occupied, fire prevention technology can increase homeowner and tenant safety immediately.

About Pioneering

For more than a decade, Pioneering Technology has been an “energy smart” technology company and North America’s leader in innovative cooking fire prevention technologies and products. Our mission is simple: To help save lives and property from the leading cause of household fire – cooking fires. We do this by engineering and bringing to market solutions that make consumer appliances safer, smarter and more efficient.

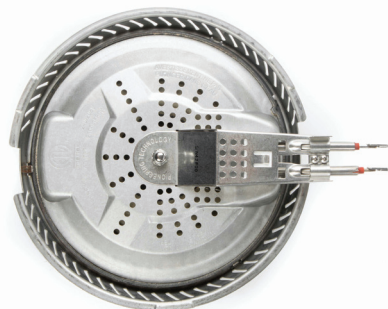
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W www.pioneeringtech.com



Contego Intumescent Paint

Contego is Latin for “to shield, defend, or protect.” Contego intumescent latex paint ensures fire protection when applied to virtually any substrate. Intumescent coatings look like a thin layer of paint, but unlike decorative paint, intumescent coatings expand considerably when exposed to the high temperatures of a fire. As the product expands, it becomes less dense and forms a tough “char” barrier that acts as an insulator, protecting the substrate underneath and blocking access to the fuel that the fire needs to grow. This passive fire protection helps to contain and prevent the spread of a fire.

Once the fire has been extinguished, extensive testing by certified laboratories has clearly shown that the resulting foam layer actually minimizes damage to the substrate. Often, the substrate may still be useable. In many instances, the protective char can be scraped off, revealing that the underlying substrate is still sound, and repair can be achieved at a fraction of the usual cost. The added fire protection gained from using intumescent paint may also decrease insurance costs.

Applying a coat of Contego fire barrier intumescent latex paint to standard residential gypsum wall board (GWB) assembly increases fire protection. A 10 mil DFT (dry film thickness) coat of Contego adds 55 minutes of burn time to any layer of GWB.

“Intumescent” is used to describe something that swells up. In the case of intumescent paint, two coats of paint swells up by several inches when exposed to the high heat of a fire. A simple coat of paint can provide added fire protection in a basement apartment.

About Contego International

Contego was formed in 2000 for the express purpose of seeking out the best fire prevention products available and expanding their use through refinement, education, and exposure. Contego is the only intumescent manufacturer that performs three separate rounds of spectrofluoroscopic FTIR analysis on its product, mapping the chemical signature of each batch to ensure superior quality control. Structures and furnishings treated with Contego brand products offer a level of security and safety that can be measured in lives and property saved.

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The two steel beams shown are treated with passive fire protection. The gray-colored beam is treated with spray-applied fire protection that results in an oatmeal-like texture. The white beam is painted with Contego's nontoxic, noncarcinogenic intumescent paint, achieving equal fire protection and an architecturally desirable finish. ▼



To see this innovation presented at the *Housing Innovation Lab: Basements* event, visit chpcny.org/housing-innovation-lab-basements

Housing Innovation Lab Event



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Conclusion

Since its founding in 1937, CHPC has helped the city's housing stock better meet the needs of its residents. Today, the city's unmet housing needs primarily impact its low-income residents, many of whom struggle to pay their housing costs, are experiencing homelessness, or rely on the informal housing market to access affordable housing. CHPC continues to study the role of basement apartments in helping to meet these needs by providing a critical supplement to the housing stock that primarily serves low-income New Yorkers.

New York City's basement apartments largely exist outside of the formal housing market and are unregulated as a result. Many people faced with the pressing need for a place to live will accept the risks of an informal rental arrangement to access a unit they can afford. Meanwhile, homeowners who want to legally convert their basements are faced with a tangle of building code requirements that are difficult and expensive to meet.

While there is widespread agreement that housing must, above all, be safe and habitable, the requirements of the building code often prohibit basement conversions, without necessarily ensuring safer or better living conditions. Policymakers are obligated to make basement units safer and more habitable, to protect tenants, homeowners, and first responders. Facilitating the safe and legal conversion of basement apartments could also create desperately needed affordable rental supply, help homeowners become more

financially stable, and offer more diverse housing options without adding height or bulk. Alternative approaches to achieving the high standards of safety and habitability set out by the code are needed to unlock these benefits. Further, policymakers must scrutinize existing building standards to ensure that they are evidence-based and necessary, without needlessly thwarting the creation of safe new units.

Simple, cost-effective solutions that are easy to retrofit could make achieving code compliance more practical, reduce the likelihood of informal conversions, and help to enhance the safety and habitability of basement apartments. CHPC's Housing Innovation Lab: Basements initiative explores these solutions, while examining the code to ensure it is achieving its underlying intent in three areas: lighting, air quality, and fire safety. For example, supplementing windows with high-quality electric lights that mimic the circadian benefits of daylight can immediately improve the wellbeing of basement occupants. Mitigating water intrusion into a basement by installing a dimpled membrane is a best practice not mandated by the code. Allowing the use of flexible plastic pipes, instead of the required metallic pipes, would make sprinkler retrofits faster, less invasive, and less expensive.

Housing Innovation Lab: Basements work is intended to inspire readers to reexamine how we view and regulate safety and quality of life in New York City's basement apartments.



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