urban green

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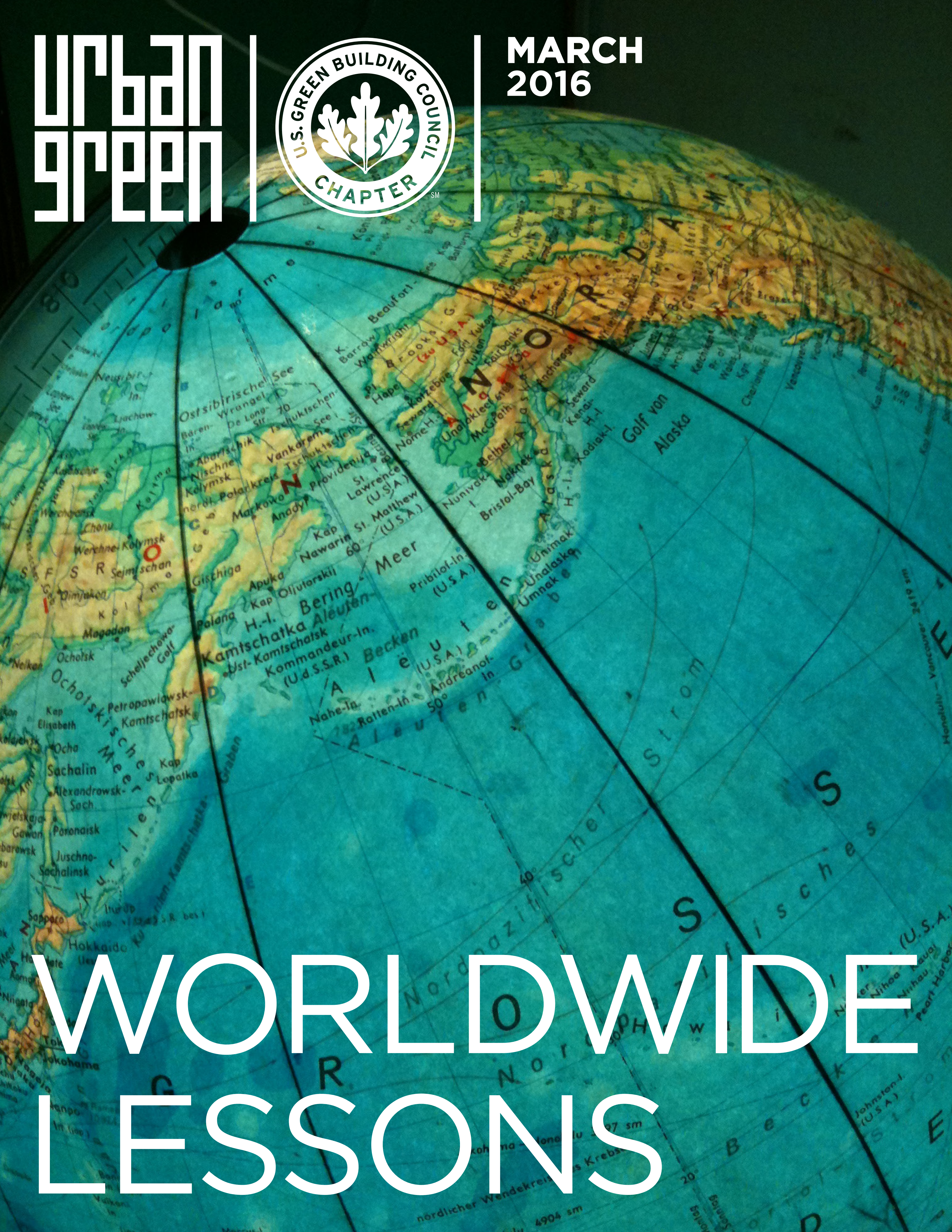

WORLDWIDE LESSONS

Urban Green Council
Urban Green Council is the New York affiliate of the U.S. Green Building Council (USGBC). Our mission is to transform NYC buildings for a sustainable future..

A nonprofit organization established in 2002, we believe the critical issue facing the world today is climate change. Our focus on climate change requires us to focus on energy and other resource management.

As we improve energy and other resource management, we can deliver a more resilient, efficient, healthy and affordable city.

For the full technical report, please visit www.urbangreencouncil.org/worldwidelessons.

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INTRODUCTION

Frankfurt and other German cities are renowned for their commitment to quality construction and engineering. London is filled with historic and diverse buildings. Singapore is famous for its direct regulation of behavior. Sydney and the rest of Australia attempted to put a price on carbon. San Francisco is a legislative testing ground. What can we learn from these cities? Are there design, policy and construction techniques that make sense in the heat of Singapore or the cold of Frankfurt that can translate to New York's climate?

New York City is the largest city in the world to mandate carbon reductions of 80% from 2005 levels by 2050. We evaluated energy codes and building industry practice in Frankfurt, London, San Francisco, Singapore, and Sydney to suggest ways to advance New York City's efforts toward this and other sustainability goals. Key trends among the peer cities show that:

1. Energy codes based solely on performance result in building stakeholders making decisions that lead to greater energy efficiency.
2. Building labeling communicates operational energy consumption and involves the public in efficiency improvements.
3. Joint classroom and on-the-job education for construction workers raises the overall quality of building construction.

Overview

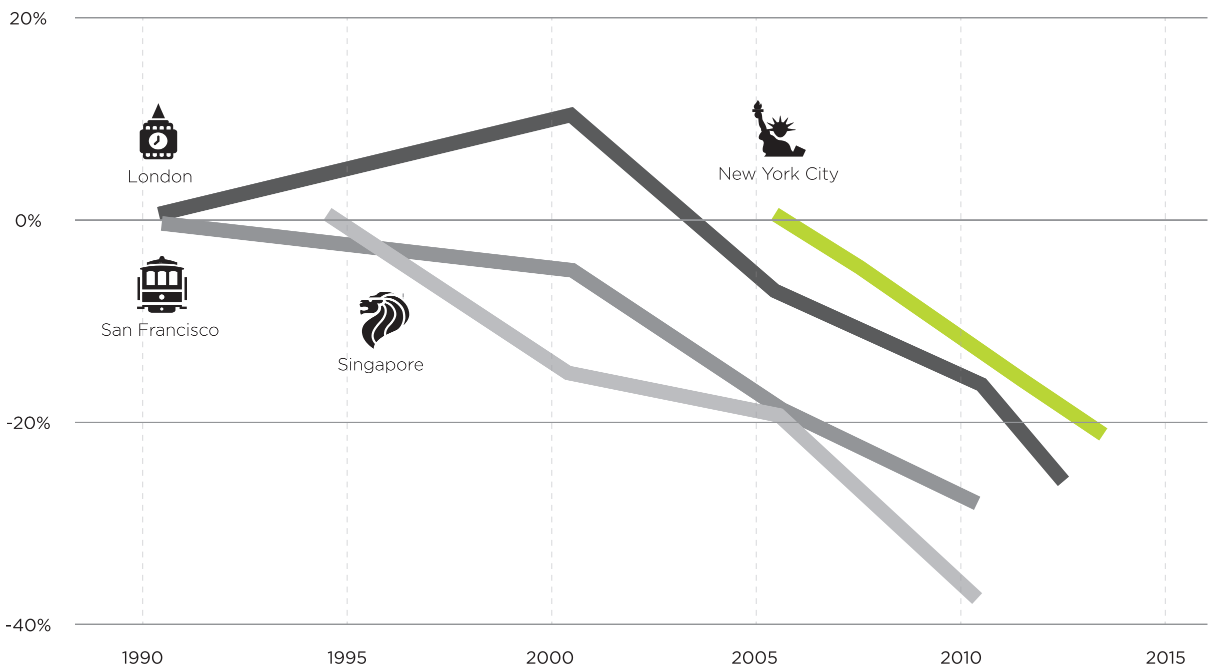


Fig. 1 Change in Building Emissions per Capita

All the cities studied in this report established goals to reduce emissions, and some are outpacing New York City. Frankfurt and London have been tracking emissions for decades and were early adopters of carbon reduction goals, which is noteworthy given the time required to see changes in citywide emissions. The United Kingdom signed on to the Kyoto protocol in 1990 and passed its Climate Change Act in 2008. Singapore instituted a government-led building-rating program in 2005 called Green Mark. San Francisco has been tracking its emissions in an inventory since 1990. Frankfurt implemented its building energy code in 1977 along with the rest of Germany, with a performance-based metric added to its code in 2002.

In New York City, designers may choose either a prescriptive or performance path to comply with the energy code. On the prescriptive path, regardless of how well a building performs overall, its walls, windows, and other features must comply with strict rules set out in a variety of tables. New York's performance path is based on a building's annual energy cost, so the price of fuel influences system decisions. Frankfurt, London, and San Francisco measure emissions or energy per building, tying compliance to the code's purpose.

If buildings were cars, the approach taken by New York and most American cities would be like regulating vehicle weight and engine size rather than simply mandating overall fuel efficiency.

While New York City has successfully implemented a building energy benchmarking program, other cities, such as London and

Frankfurt, have taken this strategy one step further. They require public labels that disclose building performance, making building owners and occupants more accountable for their energy use. In London, the label is tied to minimum performance requirements upon the sale or lease of a property.

The European Union created a standardized system for improving training for construction workers. This federal approach helps spread best practices and integrates workers across various trades and locations. Both trade schools and employers drive workforce education in Frankfurt and London. In this system, both workers and their employers can make the decision to seek additional education. This allows workers to take charge of their own education to open more job opportunities, and it creates a pathway for companies to ensure that future projects have highly skilled workers.

Climate Comparison

The six peer cities experience a range of conditions, from tropical to stable four-season climates. Of the many factors characterizing climate, humidity, solar radiation, and temperature affect building energy usage most. From an energy perspective, New York's climate is similar to Frankfurt and London, but with more extreme high and low temperatures. These three cities consistently fall below the freezing mark each winter, while San Francisco and Sydney have fairly mild climates and receive a substantial amount of annual solar radiation.

	Frankfurt	London	New York City	San Francisco	Singapore	Sydney
Annual Heating Degree Days	5,570	4,180	4,555	2,689	0	1,245
Annual Cooling Degree Days	308	222	1,259	144	6,430	1,140
Annual Precipitation	25.8 in.	40 in.	42.1 in.	19.7 in.	84.7 in.	43.5 in.
Annual Incident Solar Radiation*	67 kWh/ft2	69 kWh/ft2	123 kWh/ft2	165 kWh/ft2	64 kWh/ft2	135 kWh/ft2
Heating Design Temperature**	15˚F	31˚F	13.9˚F	39˚F	74˚F	43˚F
Cooling Design Temperature**	88˚F	83˚F	92˚F	83˚F	92˚F	91˚F

* Horizontal incident radiation
** Design temperatures based on 99.6% heating drybulb and .4% cooling drybulb.

Fig. 2 City Climate Breakdown

Building designs take into account not just the range of weather conditions, but also their frequency. Theoretical peak design temperatures — in New York, 14°F in winter and 92°F in summer — do occur, but on most days, temperatures don't reach these extremes. This frequency is measured by "degree days," the total difference between outdoor and desired indoor temperatures for each hour totaled over the year. All else being equal, more degree days mean more need for heating and cooling.

The more extreme the climate, the bigger the design challenge. New York may have the most difficult climate of all the cities studied, because large equipment is needed to meet the possibility of very hot or very cold days, even if they occur rarely. Frankfurt has a similar pattern, but its summers and winters are not quite as severe. Singapore is very hot and humid in summer, but requires no heating at all.

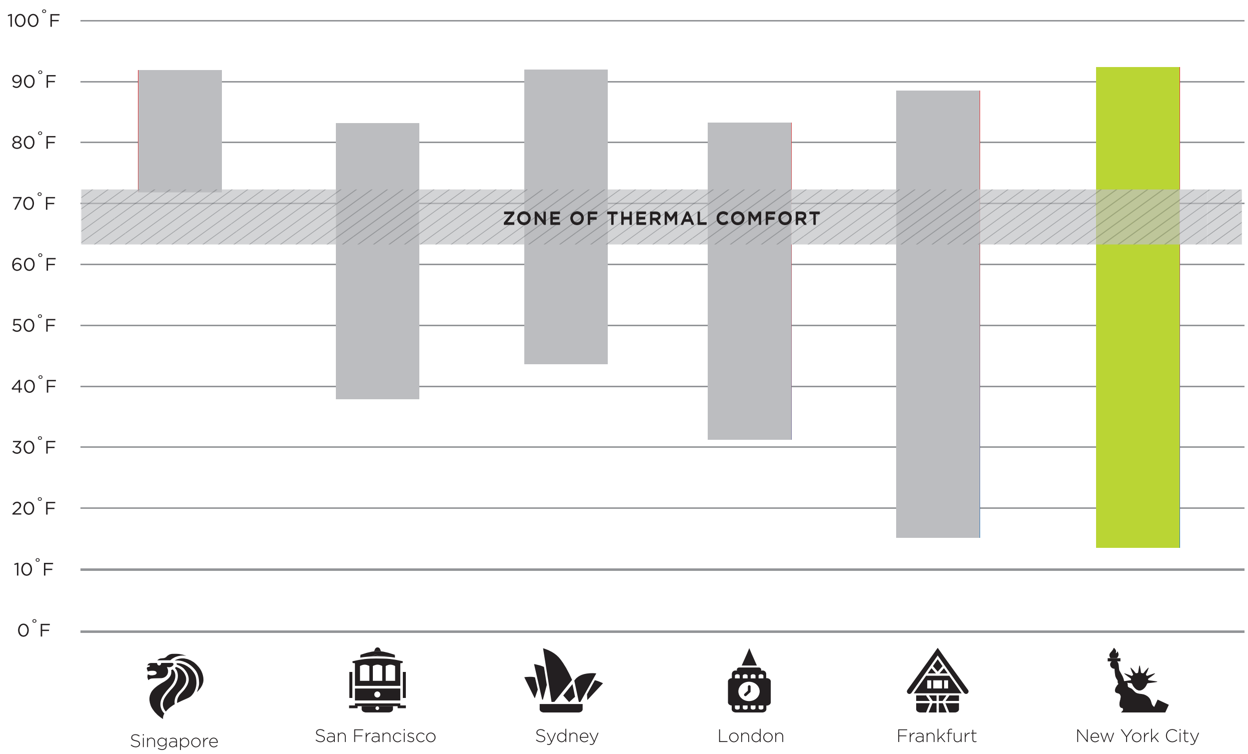


Fig. 3 Design Temperature Range for Heating and Cooling

KEY TRENDS

Energy Code Development and Structure

Each of the peer cities regulates new construction with an energy code, which has been designed to either focus on overall energy outcomes or individual requirements for building systems. NYC's energy code is "prescriptive," meaning it specifies minimum or maximum values that each component and system must meet. Compliance can also be demonstrated through computer modeling to demonstrate that energy cost will not exceed that of a comparable prescriptively designed building. However, this path still limits designers. It contains mandatory requirements, and more important, comparing costs means that fuel prices influence energy efficiency decisions. As codes aim for higher levels of stringency, these prescriptively based approaches become increasingly restrictive, limiting design and architectural flexibility.

In response to this dilemma, London, Frankfurt, and San Francisco have developed codes based on overall emissions or energy use, rather than prescriptive requirements. This approach offers several advantages:

Code development, and the metric that each building must meet for compliance, can be directly aligned with carbon reduction goals.

London follows a national code ("Part L") with local requirements that exceed code by increasing the amount of required carbon reductions. Project teams are allowed to find alternative solutions if they can't meet code requirements directly. For example, if a building design projects higher energy use than allowed by code, it might be allowed to offset this use by purchasing renewable energy.

The approach still relies on modeling, as building designs must be shown to outperform minimum requirements generated by a model. London and San Francisco use automated modeling software to expedite compliance.

The design team has greater flexibility. In London and Frankfurt, as long as designers demonstrate acceptable compliance, they must meet only modest mandatory requirements so that trade-offs can't significantly limit the overall envelope performance.

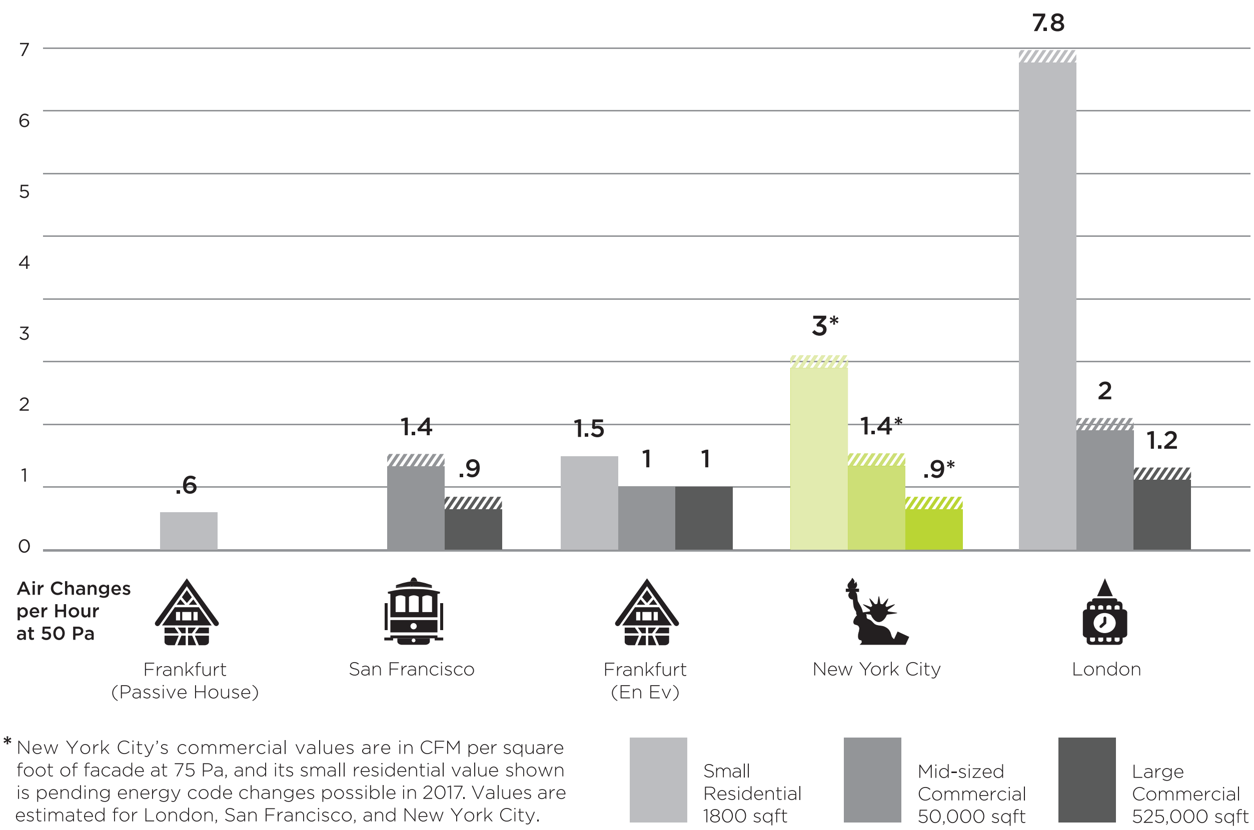
Basic Elements of Peer City Energy Codes

London, Frankfurt, and San Francisco use energy codes that regulate buildings based on predicted energy use for the whole building. Regulators create a model of the proposed building to set a baseline for the maximum amount of energy it will be allowed to use in practice. The model defines almost every detail of the envelope and HVAC systems, so its requirements ultimately determine the energy use of the building design. This summary report focused on the most important envelope requirements: air sealing, envelope insulation, and glazing transmittance.

Air Sealing

Air sealing is fundamental to ensuring comfortable, energy efficient interiors. Without proper sealing, heat leaks out in the winter, while in summer, hot and moist air enters buildings and must be removed by cooling systems. Frankfurt has the most stringent air-leakage requirements for small residential and midsize residential and commercial buildings, while New York City and San Francisco have the most stringent code requirement for large buildings. London allows more air leakage than New York City and San Francisco in its energy code. In practice, however, it has more tightly sealed buildings due to local requirements at the district level and incentives for testing.

Because air leakage depends on real-world construction practices not anticipated during design, London and Frankfurt penalize buildings that do not test air leakage. Without an actual test, designers must assume high air leakage in their energy models, making it more difficult to comply with the code. For many buildings, it's easier to comply by testing.



* New York City's commercial values are in CFM per square foot of facade at 75 Pa, and its small residential value shown is pending energy code changes possible in 2017. Values are estimated for London, San Francisco, and New York City.

Fig. 4 Maximum Allowed Air Leakage

As of 2016, New York City's commercial building code requires only visual inspections for proper air sealing but does not require leakage testing. By 2017, residential code will likely adhere to the national code at roughly twice the leakage that Frankfurt allows. Different cities use different methods for measuring air leakage, so Figure 4 estimates air leakage in air changes per hour using three reference buildings of the same size across the cities. This introduces some uncertainty in the rates for certain cities (indicated by hash marks in Figure 4). Sydney and Singapore have not developed metrics for air leakage.

Insulation

Insulation helps keep buildings warm in winter, so cities in cooler climates generally have more stringent insulation requirements. London and Frankfurt have the most stringent requirements, with San Francisco, New York City, and Sydney significantly less so. Compared to its peers, New York City's insulation requirements are lower than one would expect based on the local climate.

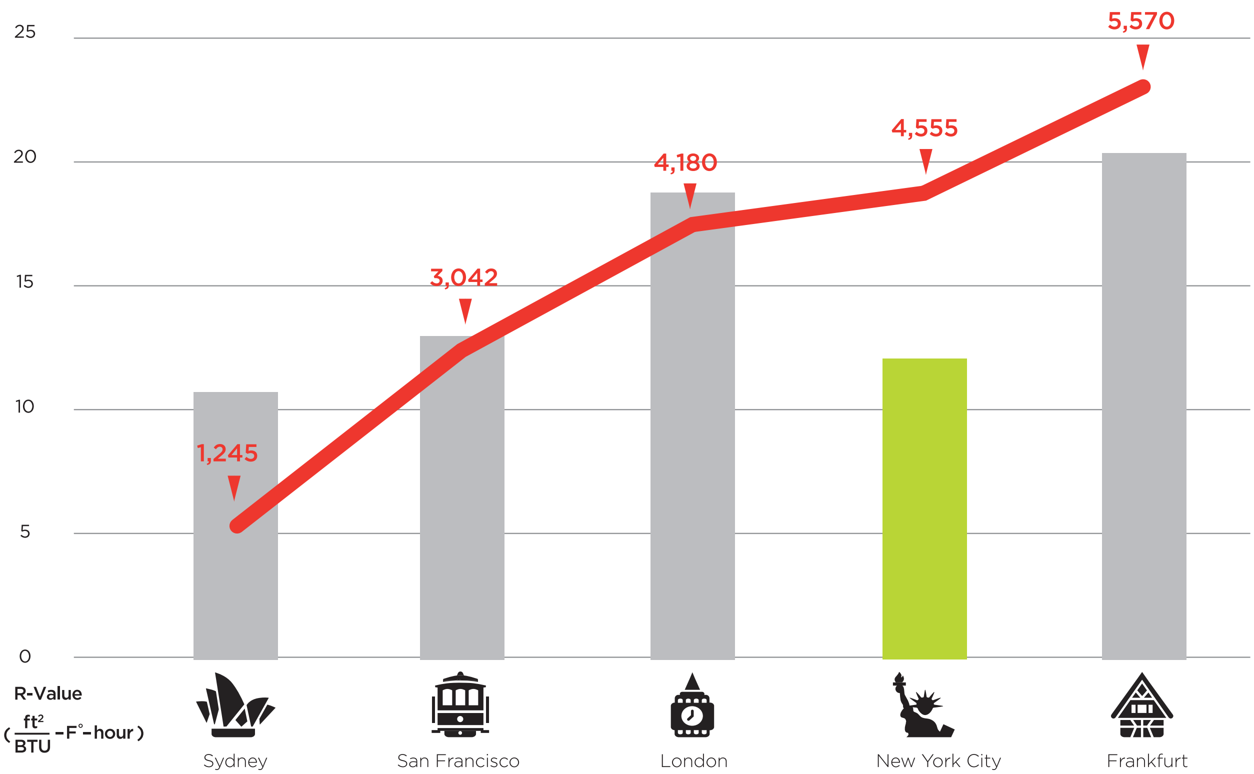


Fig. 5 Minimum Required Residential Insulation

Windows

Windows allow sunlight in and typically conduct about five times more heat than walls, which adds to both heating and cooling requirements. Not surprisingly, cities in warmer and sunnier climates generally impose stringent requirements on windows. To measure the heat gain from incoming sunlight, glazing is evaluated based on its solar heat gain coefficient (SHGC). This number ranges from zero to one and indicates roughly the proportion of solar energy allowed to pass through the window. Figure 6 shows the proportion of radiation that is blocked by a code-compliant window compared to the annual sunlight exposure for each city.

London lives up to its cloudy reputation, so its windows allow the most light and heat to enter. Singapore is also cloudy, but requires windows to block more sunlight than London. San Francisco and Sydney have the most stringent requirements, with Frankfurt, and London significantly lower in their required performance. New York falls in the middle.

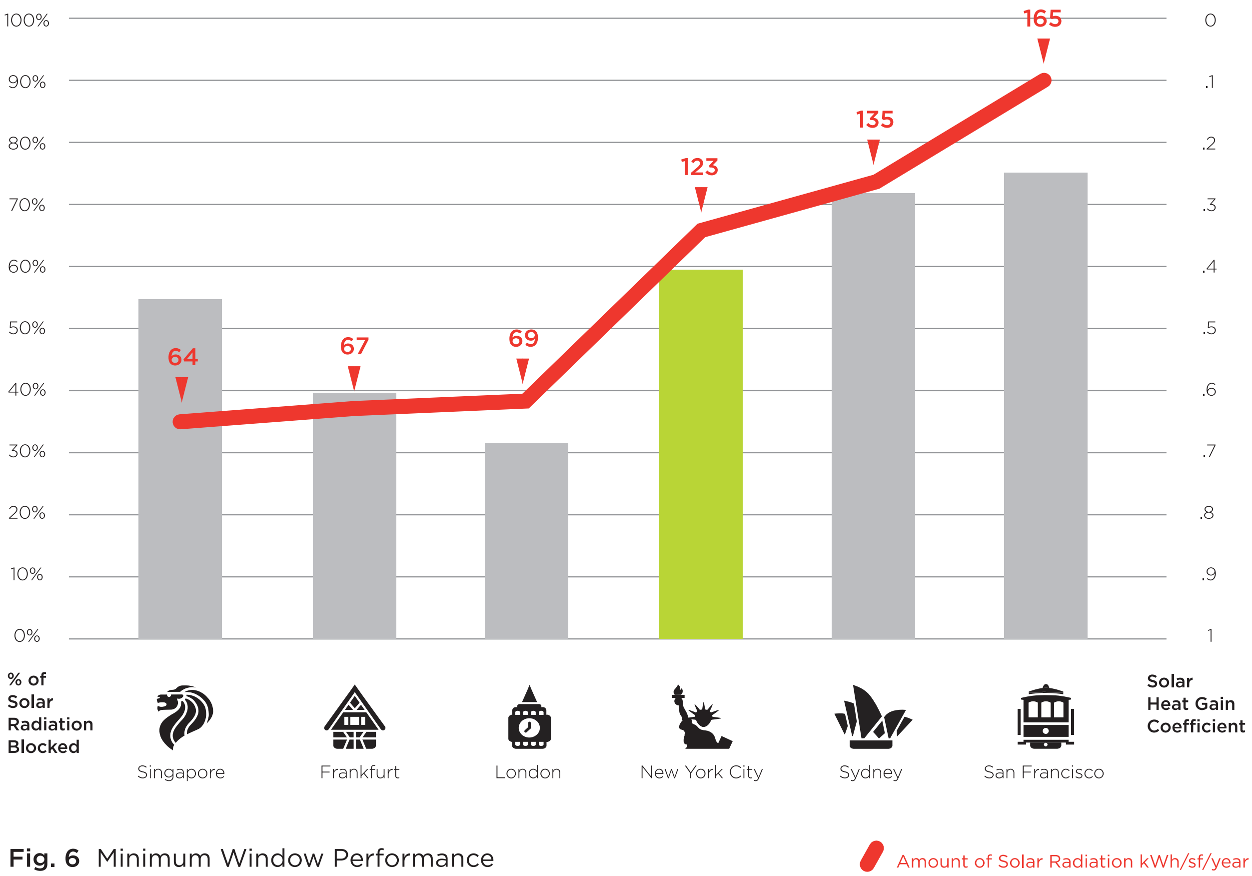


Fig. 6 Minimum Window Performance

Appliances and Plug Loads

Historically, attempts to reduce building energy usage have focused on large, central systems under the control of building operators: the heating, cooling, ventilation, and lighting systems. As these systems become more efficient, the energy used by plugged-in equipment, elevators, kitchen appliances, and data centers becomes a larger proportion of energy use. However, energy use by these appliances and electronics is difficult to track since they are installed by individual tenants, and their energy consumption is hard to measure directly.

Passive House covers all building energy use, which inherently limits appliance and equipment energy consumption. Frankfurt has taken the impressive step of requiring the Passive House standard in its municipal buildings. Nearby Brussels has also looked at Passive House for inspiration. The Belgian capital initiated a multi-year low-energy building competition, coupled with wide-spread training afterwards. The effort was successful enough to result in a new 2015 energy code based on Passive House that applies to all new construction and retrofits.

In the United States, San Francisco has efficiency standards for equipment including refrigeration, data centers, kitchen exhaust, and compressed air systems. New York has requirements on motor efficiency and elevator setbacks. Regulations also require that occupancy sensors control half of the plug loads for some buildings, but anecdotally, this practice is rarely implemented.

Building Labeling

In London and some other major European cities, Energy Performance Certificates are used to communicate energy use in existing buildings and new construction with a public labeling system. London requires minimum energy performance of existing buildings upon lease or sale. This has a wider effect than improvements to the energy code, since code affects only new or substantially renovated buildings. Legislation has also been proposed that would require some minimum performance before residents can move in. Frankfurt also has a building performance certification program, but it is limited to buildings over 1,000 square meters and allows actual or predicted usage to be displayed.

However, buildings are subject to government audits, so there is a check in place to ensure that the certification label represents reality.

These energy labeling systems are analogous to the restaurant labeling system currently used in New York City. That system is run by the New York City Department of Health and Mental Hygiene to examine the cleanliness of restaurants and then assign each establishment a letter grade based on its performance. New York City has already taken the first step toward energy labeling with its benchmarking law, but London and Frankfurt make the information easily accessible, giving it greater influence over the real estate market.

Workforce Education and Training

While globalization has removed some of the variation in global construction practices, key differences remain in workforce training and delivery models. In European cities, construction trades incorporate formal apprenticeship programs, continuing education, certification opportunities, and salaries that make skilled labor an attractive profession.

Germany has a dual education system in which apprentices split their time between vocational classrooms and practical on-the-job training at construction companies. Trainees are paid for their time, even in the classroom, and many end up working full-time at the companies where they trained.

	Frankfurt	London	New York City	San Francisco	Singapore	Sydney
Unionization Rate	Low	Low	Average	Average	Average	High
Training Entity	University / Employer	Employer	Union / Non-profit	Union	State	Union
Standardization	EU: BUILD UP Skills Program	EU: BUILD UP Skills Program	Local	Local	National: Building Construction Authority	Local

Fig. 7 Construction Trade Training

The German apprenticeship program establishes a recognized path for producing skilled workers, with continual curriculum updates complying with industry developments. More than 350 professions in Germany follow the apprenticeship model, with 1.5 million students trained annually.

Students can also choose to further their education by continuing at a master school, a more specialized school for skilled students. Once students graduate, they can start their own workshop, firm, or business, which could lead to further innovations in the construction and manufacturing fields.

In London and Frankfurt, under the EU BUILD UP Skills initiative, a status quo analysis of worker skills identified barriers and the additional skills required to deliver energy efficiency goals. In London, and more broadly in the UK, this has led to improved training and certification offerings, and organizations now have an easier time developing and maintaining appropriate training schemes for construction workers and craftsmen. It has also led to the creation of supplemental resources such as a manual of pre-approved construction details to streamline compliance with the energy code. A major benefit of the BUILD UP Skills initiative is the opportunity to share lessons learned across the more than 20 EU member states actively participating in the program.

Many European construction firms are more vertically integrated, resulting in tighter integration of trades, a greater sense of project ownership, more professional advancement opportunities, and closer coordination of cross-discipline systems. This also results in larger construction firms with greater ability to influence the technical quality of construction. While the construction manager/subcontractor model used in New York, San Francisco, Singapore, and Sydney allows for more flexibility and can be more responsive to economic cycles, it creates challenges in coordination, training, and quality control. This model can also make construction costs difficult to predict, since there are more parties involved, with each having his or her own incentives and approaches to dealing with project risks.

NEXT STEPS FOR NEW YORK CITY

Our findings suggest three major areas of potential exploration for New York City:

1. For its existing performance-based code, New York City should consider a compliance metric based on carbon emissions or energy, rather than energy cost. Next, it should consider providing incentives and remove barriers for designers to use the performance path instead of following prescriptive requirements.

Energy codes that rely primarily on prescriptive requirements limit aggressive energy and carbon reductions. By discouraging a whole-building approach, these codes limit flexibility in design and cost. Performance based energy codes—which regulate overall building performance rather than prescribing specific components—are used by several of the cities in this report with great success. Of all the codes studied, London's—which regulates carbon emissions rather than energy use—stands out as being most applicable to New York City. In addition to offering more flexibility, the learning curve on such a code is more streamlined: rather than learning an entirely new set of prescriptive requirements with each code revision, builders need only adjust as minimum performance is increased over time by a percentage.

2. New York City should consider building energy labeling and expanding its building benchmarking program.

New York City's current benchmarking strategy is similar to London's and Frankfurt's. Those cities also incorporate a building energy performance-labeling program, making benchmarking more effective because the labels increase market and tenant awareness of energy performance.

In London, buildings that do not meet a minimum performance level are restricted from selling or leasing the property. This creates a direct incentive for building owners to improve building performance.

3. New York City should consider a formalized approach to training and certifying its construction workforce, focusing on both skills and the awareness needed to successfully implement sustainable building practices.

London and Frankfurt have clear road maps for identifying skill gaps and improving construction workforce education.

They also have developed training courses for practical techniques, case studies, and manuals of pre-approved architectural details.

THANK YOU

Research Group

Patrick Bellew, Atelier Ten, London
Meredith Davies, Atelier Ten, London
Volkan Doda, Atelier Ten, New York
Amy Egerter, Atelier Ten, New York
Emilie Hagen, Atelier Ten, San Francisco
Nico Kienzl, Atelier Ten, New York
Claire Maxfield, Atelier Ten, San Francisco
Naree Phinyawatanya, Atelier Ten, Singapore
Younha Rhee, Atelier Ten, London
Paul Stoller, Atelier Ten, Sydney
Michael Tillou, Atelier Ten, New York
Shanta Tucker, Atelier Ten, New York
Henry Woon, Atelier Ten, Singapore
Sean Brennan, Urban Green Council
Megha Jain, Urban Green Council
Richard Leigh, Urban Green Council
Jamie Kleinberg, Urban Green Council
Cecil Scheib, Urban Green Council
Russell Unger, Urban Green Council

Advisory Committee

Greg Bauso, Monadnock Construction
Les Bluestone, Blue Sea Development Company
Jonathan Flaherty, Tishman Speyer
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John Lee, New York City Mayor's Office of Sustainability
John Mandyck, United Technologies Corporation
Gita Nandan, Thread Collective
Adrian Tuluca, Vidaris
Charlie Whitney, Turner Construction
Marc Zuluaga, Steven Winter Associates

CREDITS

Figure 1: Per Capita Emissions from Buildings

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Figure 2: Climate Comparison

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Figure 3: Heating and Cooling Design Temperatures

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Figure 4: Air Leakage Requirements

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Figure 5: Insulation Requirements

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Figure 6: Solar Heat Gain Requirements

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Figure 7: Workforce Overview

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Cover

Martin Abegglen