Jump-starting Passive House in New York City and Beyond

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ABSTRACT

To reach its goal of an 80% carbon reduction by 2050, New York City (NYC) must embrace a radical change to its buildings. The Passive House design's performance-based standard ensures occupant comfort and very low energy use. It is a pathway for NYC to transform its building stock to reach a low-carbon future. New York seeks to radically reduce its carbon emissions from buildings (60%) through regulatory and voluntary actions. Renovations and new construction of Passive House projects are beginning to emerge in NYC. Developers and occupants alike are adopting new attitudes towards high-performing, low-energy buildings due to the quality and comfort of these projects. Policymakers have taken notice and are considering incorporating Passive House design standards into the building code, but they have very real concerns about market adoption and readiness. Drawing from the experiences of other regions transitioning to the Passive House standard, such as Brussels, Vancouver, and Germany, New York is well positioned to develop and promulgate standards and implement policies to support broad scale Passive House adoption. This paper will explore the nascent success of Passive House in the NYC market and the pathways and needs for implementing a widespread, mandatory high-performance standard. Examining the process that led to Brussels' recent adoption of a Passive energy standard for all new construction, we will identify the relevant resources, training, and supply chain development that NYC will require to build awareness and expertise to seed the ground for a successful transformation toward high-performance buildings.

Introduction

New York City's commitment to an 80% reduction of carbon emissions by 2050 has quickly and dramatically raised the profile of the Passive House standard (City of New York 2015). As one of the few building energy standards with a record of delivering results that match such an aggressive goal, the Passive House standard was featured in Mayor de Blasio's climate action plan, *One City: Built to Last*, and has since been the subject of intense focus by public and private stakeholders in both the City and State.

Passive House is a rigorous and voluntary standard for energy efficiency in buildings. It depends on a well-insulated building envelope, air-tight components, and continuous ventilation. It can save more than 70% of heating and cooling costs compared to a typical code compliant building. There is a small but growing population of passive projects in New York (Bhasin, Frank, and Yancey 2015). New York has one of the largest populations of certified passive house professionals in the country, with training courses offered by several organizations. This paper examines the challenges inherent in building passive, including regulatory barriers, lack of education, lack of institutional support for high efficiency or passive projects, the need for a robust supply chain, and the uniquely dense urban fabric of the city.

To understand how to best support this growing movement, we examined transformative passive house policies from other cities, like Vancouver and San Francisco, and from pioneering European countries, like Germany, Austria, and Belgium. Each has either adopted Passive House standards for new construction or created fast-track pathways for projects pursuing Passive House certification. We end this paper by outlining near term steps the City and State might take to scale up Passive House adoption in New York. Other jurisdictions can offer pertinent examples and significant lessons, but NYC must develop a road map that suits the particular needs and challenges of the largest real estate market in North America. Potential components to the City's path forward include: leading adoption through public building retrofits and new construction; engaging the private sector through a low-energy building competition; removing regulatory barriers and creating code pathways for Passive House certification; creating direct incentives for builders and designers; and studying the plausibility of Passive House within the major segments of City building stock. The potential impact of Passive House is tremendous, providing one of the very few realistic paths to NYC reaching its climate action goals.

New York City Context

Building Stock

The Passive House standard is applicable to the vast majority of New York City buildings. From single-family residences and large-scale multifamily buildings to schools and fire stations, the standard has the potential to greatly improve comfort for building occupants while massively reducing energy use. Building or retrofitting to the Passive House standard also improves the resiliency of buildings during natural disasters, significantly extending occupancy, while heating and cooling systems are unable to function.

Applying Passive House standards to 1-4 family homes will only impact up to 26% of the energy use. NYC seeks to better understand how to apply Passive House standards to buildings over 50,000 square feet, which represent over 50% of the built area and 60% of the energy use of New York City (TWG 2016). These large buildings often host high-intensity electrical and thermal activity, like data centers or trading floors, making it far more difficult to meet the standard. Additionally, the low vacancy rate of New York City buildings presents an enormous challenge to completing the building envelop retrofits that would be necessary for these structures to meet Passive House requirements. Additional challenges are meeting city building and energy codes simultaneously, scaling available education and resources, and increasing access to passive house components required to serve this market.

Passive house buildings represent a growing sector. To date, there are nine Passive House Institute certified buildings in New York State and four in NYC. There are twenty more projects underway in the City, including several large-scale developments, which will add up to over 300,000 square feet of certified projects in the next few years. The majority of these projects are residential, often low-rise, and mostly in Brooklyn and Manhattan. There are over 28 projects that have been built incorporating passive house principles, but chose not to pursue certification.

To scale this progress and ensure all building types benefit from Passive House standards, there will need to be a gradual ramp up of projects, including demonstration projects of different types and sizes that exemplify feasibility by revealing and resolving unexpected challenges.

Policy

The Passive House standard is quickly becoming an important element of New York policy discussions. Mayor de Blasio’s climate action plan, *One City: Built to Last*, estimates that the total carbon emissions of the building sector will need to be reduced 60% by 2050 to meet the overall city target of an 80% reduction by 2050. Virtually no other standard delivers low energy buildings that can meet this goal (City of New York 2015).

New York City and State are implementing initiatives that are mapping the pathway for buildings to meet the 60% by 2050 reduction target. NYC's largest initiative, the Retrofit Accelerator, is an outreach and assistance program designed by the Mayor's Office of Sustainability. It is designed to foster thousands of energy retrofits throughout the City over the next decade. Account managers will guide building owners and operators towards strategies that immediately lower their energy use, as well as long term plans that dramatically reduce energy consumption. Account managers will be provided with the resources needed to educate building decision makers and will provide actionable training and resources for designers and trades people. Additionally, there is a "high-performance" buildings track that will focus on the resources needed to retrofit buildings to a passive house or very low energy standard.

Passive House Principles

The Passive House standard is both a set of design principles and a voluntary standard for energy efficient buildings developed by the Passive House Institute (PHI), in Darmstadt, Germany. Buildings adhering to the Passive House standard are well insulated, use dramatically less energy (70-90% reductions) than typical buildings, often include renewable energy sources, and, as a result, are more resilient against power outages and extreme weather (PHI 2015). These design principles also benefit occupants, providing excellent indoor air quality, improved thermal comfort, and high ventilation rates. The Passive House standard relies on several fundamentals: deep thermal insulation of the building envelope to minimize heat loss and gain; triple glazed windows with shading that modulate heat loss or gain; an airtight building envelope; minimized thermal bridges; and continuous ventilation with energy recovery.

The Passive House standard is first and foremost about occupant comfort. Rather than simply producing the most efficient buildings, passive design endeavors to produce buildings that use the least amount of energy while providing the highest quality interior environment. Many of the performance standards and targets that have dominated the energy efficiency conversation address occupant comfort as an afterthought – looking only at ambient temperature and humidity. The needs of the occupants act as a kind of backstop to attempts at drawing down energy use. As a result, efficiency is often understood as something that largely detracts from, rather than contributes to, the needs and wants of the people and organizations that use buildings. Passive House turns this conversation on its head, with guidelines that produce the greatest comfort for building occupants, eliminating drafts, thermal bridging, and noise discomfort, while using only a fraction of the energy a typical building consumes. This remains a fundamental – and fundamentally positive – distinction from the current paradigm.

Passive design is low-tech and low maintenance, but relies on rigorous testing, quality control, and commissioning. The strict energy use limits make passive buildings ideal candidates for net-zero or net-positive energy certification. For example, the annual median source energy use intensity (EUI) for New York City commercial buildings is over 200 kBTU/SF, and the residential median is 132 kBTU/SF, while Passive House caps the EUI at 38 kBTU/SF for all building types. (City of New York 2014, 20). Figure 1 below shows the median energy use intensity of commercial and residential buildings in New York City, compared to Passive House energy use intensity. It is clear that adoption of a Passive House standard will help NYC meet these aggressive goals.

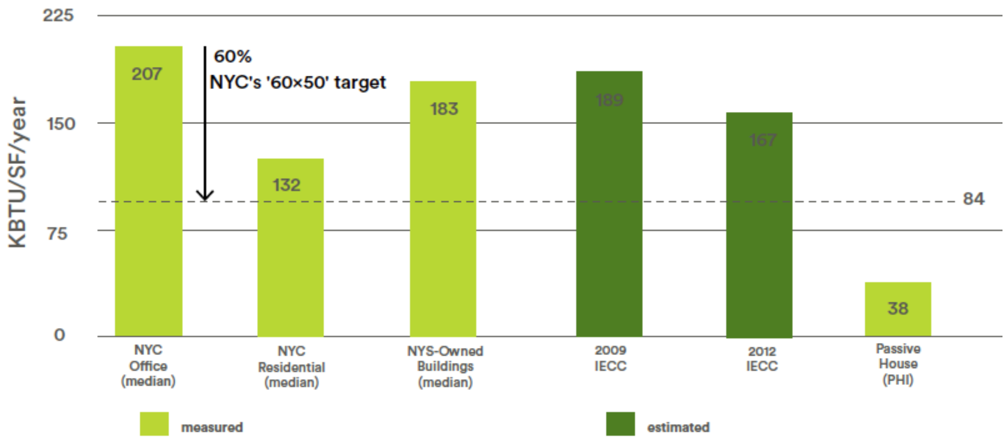

Figure 1: Source energy use intensity (EUI) comparison. *Source*: (City of New York 2014)

Passive House Energy Standards

The Passive House Institute has shown that optimum comfort and efficiency are achieved when the annual heating budget is 15 kWh per square meter, or 4.75 kBTU per square foot. Using this number as a starting point, PHI created the Passive House Standard, a continually evolving certification standard for passive projects. To ensure that Passive House principles are widely understood, PHI formally certifies organizations around the world to deliver training and professional exams and to certify projects. Besides the heating budget, the Passive House standard requires a cooling energy demand of less than 4.75 kBTU/SF/yr, with some allowances for dehumidification based on local climate, and an airtightness limit of 0.6 air changes per hour at 50 Pascals of pressure (ACH50). Other groups, such as Passive House Institute of the United States (PHIUS) and the government of Brussels, have created their own versions of the standard.

Costs

According to the Pennsylvania Housing Finance Agency, the cost premium of Passive House projects was less than 2% for state-financed affordable housing (Temple University 2015). In a recent survey of Passive House projects internationally, costs ranged from 20% less to 16% greater than a conventional project (Pembina Institute 2016). Just as LEED certified buildings initially experienced cost premiums, and are now mostly cost equivalent to conventional buildings, passive projects experience a cost premium mainly due to lack of market penetration. Additional costs are attributed to the pre-construction design phase, but can be mitigated through integrated design.

Traditional energy efficiency strategies typically add directly to project costs and pay for themselves over time through lower energy costs or other financial benefits. Because of this, it is often assumed that the reductions in energy use realized by passive house projects are also the result of cost increases. However, passive house projects are generally cost competitive, as increased investment is focused on inexpensive materials like insulation and air barriers. Additionally, the high performance envelope is offset by the decreased costs of heating and cooling systems. There are examples of passive house style retrofits being less expensive than traditional projects. For example, upgrading the envelope significantly beyond code requirements eliminates the need for supplemental heating & cooling systems. Cost of ownership is often lower for a passive house because energy costs are massively reduced and because more dollars are invested in higher quality, long-life components, like windows.

Challenges

Despite the potential of the Passive House standard, there are significant challenges to widespread adoption. Building professionals and policymakers cite several technical factors holding back the passive house movement in New York, including the high intensity uses and massive number of existing buildings, as well as an immature supply chain. While the passive house community in New York is strong – the largest concentration of Passive House trained professionals in the US, according to New York Passive House (NYPH), with 50-100 PHI certified designers and consultants and just under 50 certified tradespeople – there is still much training to be done to reach scale. There is also a need for demonstration projects to provide living examples for the rest of the industry. NYC's vast existing building stock, as well as its robust and diverse building uses, creates unique challenges to widespread implementation of passive design principles. The limited availability of key passive building components and equipment is also a challenge, as are certain existing regulations.

High Energy Intensity Buildings

While the backbone of the Passive House standard is a strict limit on the energy used to heat and cool buildings, there is also a strict limit on total primary energy demand, including plug loads. The lack of regulation of plug loads, in the US, has led to significant inefficiencies. Corporations that have moderated energy used for computers, printers, and other devices routinely find that reductions of 30-50% can be achieved without compromising business functions. Nonetheless, applying a total energy demand cap to NYC buildings would require specific and extensive study, with any solution presumably brought very gradually into the market. Many of NYC's most visible buildings are the seats of high-profile industries, including finance, media, telecom, and health care. The energy use profile of these buildings differs dramatically from basic office and residential buildings, with many having local data centers and complex lighting and ventilation systems. While the principles of Passive House can be applied in virtually any situation to produce highly efficient buildings, the strict limits on energy demand are not always easily achieved by these high intensity office buildings, where occupants are densely packed and might work alongside data centers or broadcast studios. In the multifamily market, larger buildings are often dominated by internal loads, reducing the impact of envelope improvements and typically requiring a focus on cooling in all seasons. While investigating the feasibility of Passive House, NYC will need to determine how to overcome this challenge, whether through technology innovation (such as smart strips, etc.) or offsetting this energy use through on-site renewables.

Existing Buildings

Perhaps one of the most significant challenges to adopting a passive standard is its application to existing buildings. To address the unique challenges of retrofitting existing buildings, the Passive House Institute has developed a separate standard, called EnerPHit. The EnerPHit standard has a strong track record in Europe for bringing ultra low energy use to a wide variety of existing building types. Recognizing that there are many fixed attributes of existing buildings (such as window location, massing, and orientation), PHI has developed less restrictive criteria for heating and cooling energy use, and makes exceptions for projects with additional requirements or restrictions. The EnerPHit standard has been revised to include seven climate zones in PHI's PHPP software[1], with appropriate heating and cooling energy limits for each zone. As with new buildings, the revised limit for primary energy demand is based on three renewable primary energy (PER) categories: Classic, Plus, and Premium. Unlike the PHI Standard for new buildings, the EnerPHit requirements for renewable energy are based on a series of calculations, yielding specific energy limits for each project.

Through a broad demonstration program, called EuroPHit, the EnerPHit standard has been applied successfully to multiple building types across Europe. The EnerPHit standard can be achieved by using required components for a project or by achieving a certain energy demand based on the climate zone according to the PHPP modeling software. Pursuing EnerPHit is most feasible in situations where an entire building is unoccupied and available for extensive renovation. The pragmatic challenges, for instance, upgrading a façade from the interior while the building remains occupied, can hardly be overstated. The creators of EnerPHit have recognized this and promote a long-term phasing plan that provides credit for reaching early milestones on the way to full EnerPHit certification. As 90% of NYC's building stock will still be standing in the next 50 years, it is likely that a program similar to EnerPHit will be needed to bring NYC buildings to meet a passive house standard (City of New York 2015). Careful study will be required to determine if requiring long term deep retrofit plans is feasible for New York City, and how such a system might be implemented and administered.

Supply Chain

With only a few hundred projects in the US following passive design standards so far and with the majority those being small residential buildings, there are Passive House components and equipment that are difficult to obtain in the US, especially components required for large, multi-story buildings. Companies looking to supply products to the US must navigate specific regulatory demands, be confident that tradespeople are able to properly install and commission their products/systems, and have adequate local representation to manage customer service demands, including maintenance and potential repairs. Current supply chain issues include: windows and doors, curtainwalls, tapes and membranes, energy/heat recovery ventilators, and thermal break materials. It is anticipated that market demand, created by more and larger projects, will resolve these supply chain issues, but a coordinated policy approach could help provide greater and quicker access to critical passive design components.

Regulatory Barriers

Building and energy codes present clear challenges to passive house designers. For example, Passive House requirements for ventilation and exhaust streams directly contradict with NYC's building energy code, which requires almost twice as many air exchanges per hour (Passive House Institute 2015). In order to pursue the Passive House standard, a project must apply for and receive an exemption from the City. Historic and landmarked buildings pose their own challenge, as any changes, such as window operation, will result in a hearing. This slows the

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[1] PHPP, Passive House Planning Package, is a software tool developed by the Passive House Institute, that calculates the energy efficiency of a building for architects and planners.

permitting process significantly. Finally, Passive House originated in Europe, and many Passive House compliant technologies, such as windows are based on European metrics. US vendors do not generally provide the same metrics, so translation is required.

Additionally, passive design often relies on overhangs and external shading to achieve lower energy use. This is difficult to do in New York City without violating lot lines and zoning requirements. Fire code restrictions dictate what insulation can be used on mid to high-rise building exteriors, restricting options for building envelopes. These barriers result in added time in both the design and purchasing phase of a Passive House project in New York City and must be addressed through policy changes to speed the transition to more energy efficient buildings.

Education

There are significant knowledge gaps about passive design and construction among building stakeholders. The successful introduction of a passive house standard across the New York City building sector will require extensive education of virtually every stakeholder group, from owners and designers to tenants and contractors. This effort will likely be similar to the introduction of the US Green Building Council's LEED building rating standard to the marketplace. There are currently a limited number of existing educational programs, delivered regularly in New York City; and New York State currently provides financial support for some training programs. If not renewed, however, this subsidy for training tuition will expire at the end of 2016. Widespread education will raise interest and drive demand for passive design and will also reduce friction for projects in flight.

Passive Regulation Survey

Several cities and regions around the world have integrated passive or low energy design standards into their codes and regulations. In New York City, the Passive House Standard was referenced in Mayor de Blasio's climate action plan. In Marin Country and San Francisco, California, the Passive House Standard is currently part of planning policy.

Some of the frontrunners in the passive house movement are European cities, like Brussels, Belgium; Heidelberg, Germany; and Tyrol, Austria. Other aspiring cities and regions not listed in Table 1 include Aquitaine, France; Burgas, Bulgaria; Cesena, Italy; Wales, UK; and Zagreb, Croatia. Most of these cities have in place government initiatives and legislation, often beginning with public buildings. Table 1 is an initial sample of various municipal and regional passive standard initiatives. More information can be found on the International Passive House Association's (iPHA) website.

Table 1. Passive Regulation Survey (partial)

City or Municipality	Regulation	Year Implemented
USA		
New York	The New York State Homes and Community Renewal Agency (HCR) provides financial support and tax credits to projects that aim to be more sustainable, including projects certified by the PHI or PHIUS. Additionally, Community Preservation Corporation (CPC) provides loans for energy efficient upgrades, including upgrades that achieve PHI or PHIUS standards, in multifamily units that service low and middle income families.	2015
Pennsylvania	The state of Pennsylvania's Housing Finance Agency, offers tax credits for Passive House compliance for low-income, multi-family buildings. These developments do not have to be certified, but have to meet performance criteria with third-party consultants that are Passive House certified.	2015
San Francisco, CA	Passive House or EnerPHit certification is eligible for priority processing from the planning department.	2014
Marin County, CA	Building code amended to include the definition of a passive house building. The code encourages green building with creative incentives for compliance with one of several green building standards.	2014
Abroad		
Vancouver, Canada	Sets Passive House as an alternative to LEED in their Green Buildings Policy for Rezoning. Planned developments requesting rezoning need to achieve LEED Gold status with a 22% reduction in energy costs, as compared to ASHRAE standards; or to achieve Passive House. To ensure no delay in processing applications for Passive Houses, the City provides training on passive design and construction to city staff.	2015
Brussels, Belgium	Brussels' PEB standard is a modified version of the Passive House standard that was formalized in 2009, at which point all new public buildings had to adhere to the standard by 2010. All new and heavily renovated buildings had to meet the PEB standard as of January 2015.	2015
Oslo, Norway	In Oslo, all new public buildings need to be built to the Passive House standard as of 2014.	2014
Villamediana de Iregua, Spain	This is the first Spanish municipality to adopt Passive House standards for all public buildings, and 10% of all housing within new urban developments.	2013
Tyrol, Austria	Energy Strategy Tyrol 2020 is a mix of energy efficiency policies and incentives focused on heating and cooling demands and renewable energy use – the maximum heating demand must be 25 kWh/m2/yr to avail of housing subsidies	2013
Heidelberg,	New municipal buildings are required to meet the Passive House	2010

Germany	criteria, verified by the PHPP. Plots of land bought from the city will be required to comply with Passive House. The city also has a new district that is entirely Passive House compliant.)	

(Bhasin, Frank, and Yancey 2015)

Lessons from Brussels

The Brussels Capital Region has experienced an energy revolution in the last ten years, transforming themselves into one of the front-runners in the passive house movement. Nearly ten million square feet of passive house buildings have been built or retrofitted in the region as of 2014. Through major government initiatives and financial support, Brussels is demonstrating that passive house design can be affordable, practical, and efficient. Between 2004 and 2010, Brussels' energy consumption reduced 10% while population and employment have increased (Dockx 2013). The region has accomplished this through a combination of extensive training and support for professionals and tradespeople interested in low energy buildings; a leading-edge competition to provide built examples; a coordinated effort between government agencies; and the development of a robust supply chain of energy efficient components.

BatEx Competition

The Brussels-Capital Region began a call for 'Exemplary Building' (Bâtiments Exemplaires, or BatEx) projects in 2007. The goal was to stimulate demand in the sustainable buildings market, to demonstrate the technical and financial feasibility of green construction, and to recognize excellence in for environmental performance and energy efficiency. The Region's objectives were to disseminate knowledge, stimulate the building and design communities, and create public awareness and ownership through demonstration. In the long-term, the program is creating market demand for energy efficient buildings, and in the short term, the city is reaching a critical mass of energy efficient buildings needed to start progressing towards the European Union's Directive of all new buildings being nearly zero energy by 2020 (Deprez 2015).

After 6 calls for projects, BatEx has granted $36 million to 243 projects over seven years. These projects had to fulfill four criteria: (1) strive towards defined passive standards; (2) prioritize environmentally friendly construction; (3) demonstrate good architectural quality and integration with the existing urban fabric; and (4) be replicable in technical and financial terms. The grants are open to a wide variety of projects and developers; effectively all projects being built or renovated in the Brussels-Capital Region are eligible. Submissions may be new construction or renovations, single-family or collective housing, public facilities, office, commercial, or industrial use. The size of the participating projects varies widely from as small as 1,300 square feet to 108,000 square feet, and 39% were renovations.

The winning teams sign contracts with Brussels Environment Administration and receive subsidies once projects are underway. Winning projects must be completed within four years of the award and provide energy consumption reports to the government for the first five years of operations. After construction, the project is evaluated for its energy efficiency and is then labeled an exemplary building. Once the site is officially recognized, the winners receive additional publicity and technical support. Awards are capped at $^{\pm}$\$120,000 per project, with 10% allocated to the project's design and engineering and 90% to construction.

Of the winning projects, more than half are designed to the Passive House standard: a total area of almost 4 million square feet by 2017. While the Passive House standard was an optional goal, more and more projects chose it as their target each year of the competition.

The selected projects included affordable housing units (66% of which achieve Passive House Standards), hospitals and schools (a quarter of the winning projects are dedicated to public use), iconic and historic office and retail buildings, and 1,866 housing units. The BatEx awards have been distributed between public, private, and non-profit projects (Deprez 2015).

Passive 2015: The Brussels Standard

Having created a passive design context through the competition, the Brussels capital region moved to codify a low-energy standard for the city in 2009, with the 'Passive 2015' agreement being formally signed in 2012 (Dockx 2013). The Brussels standard - 'Performance Énergétique des Bâtiments' or PEB - is in anticipation of the EU Directive on nearly zero energy buildings.

The PEB 'Passive 2015' standard is a modified version of PHI's Passive House standard, dealing with net heating and cooling requirements, primary energy consumption, ventilation, and airtightness of new housing, offices and schools, and heavily renovated projects (Brussels Environment 2014). The requirements are the outcome of negotiations between the government, passive standard authorities, and professional stakeholders about how to adapt the standard to the dense urban fabric of Brussels.

Both the Passive House standard and the PEB require an annual net heating requirement of less than 15 kWh/m2, or 4.75 kBTU/SF, with an allowance for overheating (above 77° F) allowed for 5% of the year (PHI 2015, Brussels Environment 2014). This is a ninety percent reduction from the standard heating use of 150 kWh/m2. PEB requires an annual net cooling requirement of 4.75 kBTU/SF for only schools and offices, whereas Passive House requires the cooling limit for all building types. The airtightness requirements remain the same (0.6 air changes per hour at ACH50), but will be phased in over four years. For residential buildings, the annual primary energy demand (heating, cooling, hot water, ventilation, pumps, and fans, but not lighting or plug loads) is 45 kWh/m2 or 14 kBTU/SF (compared to 19 kBTU/SF for PHI's Passive House Standard, which includes lighting and plug loads). For offices and schools, the annual requirement is under 26 to 30 kBTU/SF, depending on the compactness of the structure. The standard also provides an alternative 'Track B' for projects that face challenges achieving the standard (i.e. size, orientation, shading) and require custom criteria. For existing building renovations, each requirement is multiplied by a factor of 1.2, except the overheating limit.

When the standard was formalized in 2009, the Brussels government required all new public buildings to lead by example and be built to the standard starting in 2010 (Deprez 2015). As of January 2015, all new and heavily renovated buildings are required to meet the Brussels Passive standard, a goal that the city laid the groundwork for several years in advance. This process included training, technical support, and all the education that the BatEx projects have provided, over the previous seven years.

Path Forward

Learning from the experience of passive house designers in Brussels and the efforts of similar cities, provides us with tools for the future success of low energy design in New York. A road map for New York City might include the following components:

Public Buildings Leadership. If New York City required most new, public buildings to meet a passive-type standard, and some portion of existing public buildings be retrofitted to meet an EnerPHit-type standard, it would provide a dramatic demonstration of feasibility. Such a program would provide opportunities for sharing lessons across the real estate sector and drive market demand for high performance products. The Design Excellence program, administered by the New York City Department of Design and Construction, or an update to Local Law 86 of 2005 might be appropriate vehicles to drive such a campaign.

Exemplary NYC. A multi-year competition, similar to the Brussels Exemplary Buildings program, would be a very effective means of introducing passive design to the broader market. If several tiers of low energy targets were adopted (as in Brussels), it would allow the private sector to assist the City in determining the most cost effective low energy targets for the greatest number of buildings. Additionally, it would provide an excellent vehicle to absorb and broadcast lessons for the entire sector. The key components of the Brussels program include: i) a multi-year effort with significant financial and regulatory incentives, ii) design excellence and other factors alongside energy performance, iii) extensive training and resources for industry stakeholders, and iv) transparent sharing of outcomes and performance that celebrates and promotes the participants.

Passive Code Pathway. The City might study the feasibility of allowing Passive House certification as an alternate pathway to the current energy code. This relatively simple move would provide an easy road map for building owners looking to demonstrate leadership, while eliminating the need for double compliance (both PH certification and energy code) that is currently required.

Barrier Removal. Several regulatory barriers to the application of Passive House could be removed through internal City rule-making. A small task force dedicated to this effort, or an existing group, such as the NYC Department of Buildings Sustainability Board, could provide guidance on appropriate modifications.

Active Incentives. The deep energy use reduction of Passive House might be rewarded with access to greater incentives from NYSERDA and/or the relevant utilities. Targeted incentives, in addition to direct financial awards, would drive demand in the private sector and might include additional funding toward training and tool development**.**

Market Research. The City and State could direct specific study of the impacts of Passive House requirements on each major building industry segment. This might include a high level look at the specific challenges of retrofits, the feasibility of introducing plug load regulations, the impact of passive house style ventilation requirements in multifamily buildings, and the performance of passive buildings in brownouts and blackouts. Coupled with the lessons gleaned from a Brussels-style competition, such research would provide strong guidance for appropriate regulations for buildings between now and 2050.

Conclusion

To reach the projected carbon reduction goals of the Mayor's *One City: Built to Last* plan, New York City needs to build on our existing position of leadership. It is essential that we transform the majority of our buildings into low and net-zero energy use. While improvements to the energy code are underway, these are incremental, and the buildings created with it will lock in relatively high carbon emissions for the next few decades, as compared to the dramatic reduction in emissions that can be achieved by passive buildings. The Passive House standard is poised to play a significant role in the future of New York City buildings.

Passive House is the standard that:

- Most cost effectively produces ultra low energy buildings with nonpareil interior comfort
- Best positions our buildings to achieve net zero energy status
- Most improves resiliency
- Most reliably delivers actual outcomes on par with estimated benefits

While there remain challenges to implementing passive principles, particularly in certain building sector segments, like high intensity office buildings, it is clear that the passive approach can be applied to a broad spectrum of New York City buildings and could play an important part in New York City achieving its climate action goals.

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