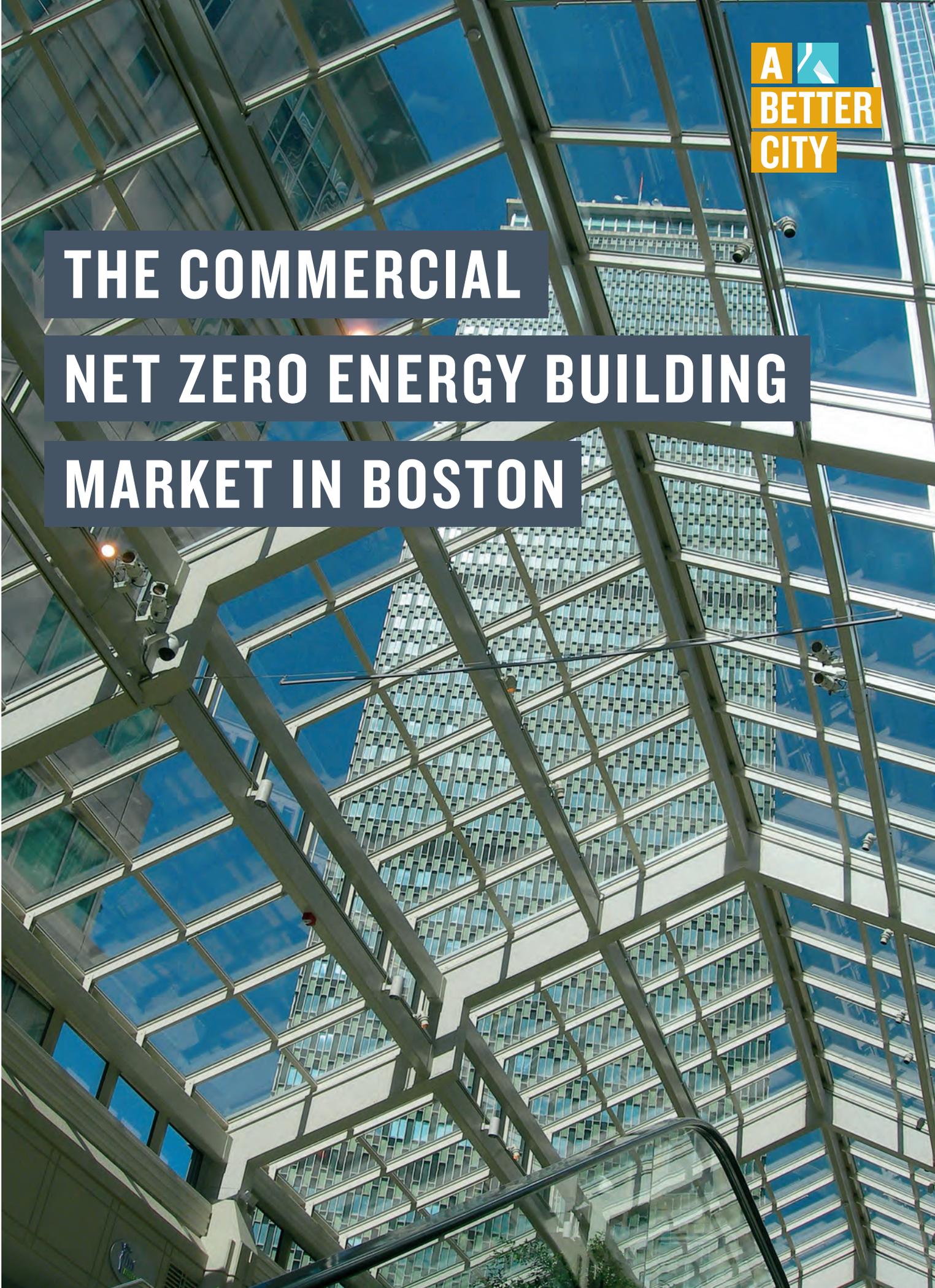


**THE COMMERCIAL**

**NET ZERO ENERGY BUILDING**

**MARKET IN BOSTON**



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A Better City is a diverse group of business leaders united around a common goal—to enhance Boston and the region's economic health, competitiveness, vibrancy, sustainability and quality of life. By amplifying the voice of the business community through collaboration and consensus across a broad range of stakeholders, A Better City develops solutions and influences policy in three critical areas central to the Boston region's economic competitiveness and growth: transportation and infrastructure, land use and development, and energy and environment.

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- Architecture 2030
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- National Grid
- The New Buildings Institute
- The Rocky Mountain Institute
- Skanska

To view a hyperlinked version of this report online, go to [http://www.abettercity.org/docs-new/The\\_Commercial\\_Net\\_Zero\\_Energy\\_Building\\_Market\\_In\\_Boston](http://www.abettercity.org/docs-new/The_Commercial_Net_Zero_Energy_Building_Market_In_Boston)

# THE COMMERCIAL NET ZERO ENERGY BUILDING MARKET IN BOSTON

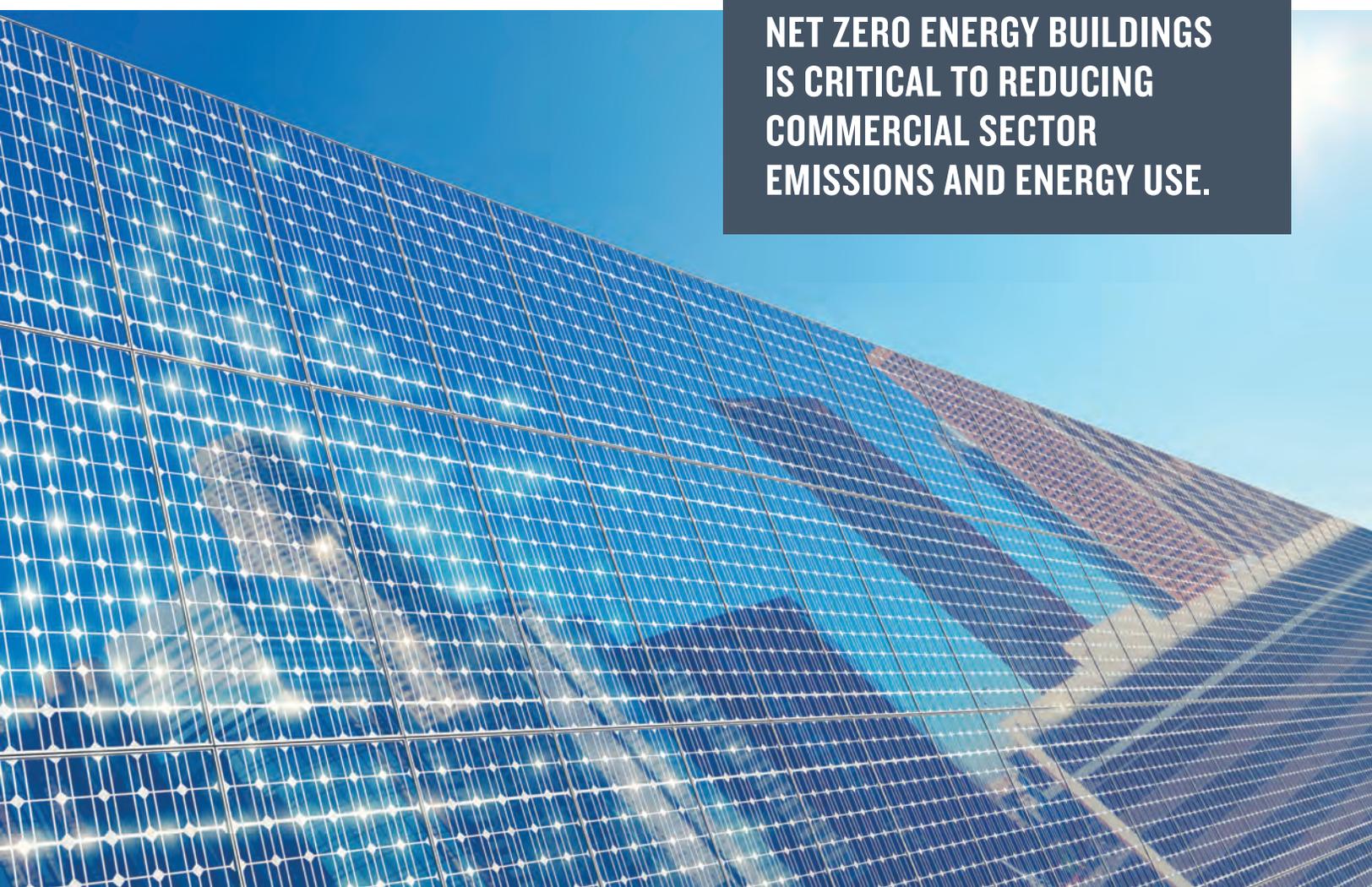
## INTRODUCTION

Commercial buildings contribute to 52.2% of the City of Boston's greenhouse gas emissions and are crucial to energy efficiency savings goals for utilities throughout the state.<sup>1,2</sup> The City and State's 2050 emissions reduction targets of 100% and 80% respectively are among the most ambitious in the nation.<sup>3</sup> To meet its goal, the City of Boston recently joined the Carbon Neutral Cities Alliance, a collaboration of international cities committed to reducing greenhouse gas emissions by at least 80% by 2050.<sup>4</sup> Massachusetts continues to be nationally recognized for its leadership in efficiency programs; the utilities have committed to an ambitious set of three-year efficiency planning targets.<sup>5</sup> Exploring

and implementing net zero energy buildings is critical to reducing commercial sector emissions and energy use.<sup>6,7</sup>

Conceptually, net zero energy buildings produce or utilize as much renewable energy as they consume on-site (see Section 2 for an extended discussion on the definitions of net zero buildings).<sup>8</sup> Massachusetts has demonstrated thought leadership on net zero energy buildings for almost a decade. At present, the Massachusetts utilities are working to develop a Net Zero Pathways custom incentive under the Mass Save New Construction program

**EXPLORING AND IMPLEMENTING  
NET ZERO ENERGY BUILDINGS  
IS CRITICAL TO REDUCING  
COMMERCIAL SECTOR  
EMISSIONS AND ENERGY USE.**



for commercial facilities.<sup>9</sup> In 2008, the governor of Massachusetts formed a Zero Net Energy Buildings Task Force to provide research and recommendations on net zero energy adoption for residential and commercial buildings. In 2014, DOER launched the Pathways to Zero Net Energy grant program to fund feasibility, integrated design, and construction of net zero energy buildings in Massachusetts.<sup>10</sup> Many of the 25 selected buildings are operational or nearing the end of their construction phases. One of these projects, Bristol Community College's John J. Sbraga Health and Science Building, was completed in 2016 at cost parity with traditional construction (see Commercial Case Studies). The Massachusetts Department of Energy Resources has also funded other high-performance building retrofits and construction projects, such as the Castle Square Apartments (see Commercial Case Studies) through other funding mechanisms like the American Reinvestment and Recovery Act.<sup>11</sup> Since the State's Task Force completed its work in 2009, some localities, such as the City of Cambridge, have launched their own policy and exploratory processes for pushing buildings toward net zero.<sup>12</sup> Regionally, New York and Rhode Island developed their own studies of net zero buildings in partnership with their local utilities and other large institutions.<sup>13,14</sup>

Massachusetts has a number of local developers who are developing net zero homes and homes that produce more energy than they consume.<sup>15</sup> In the commercial sector, early-stage market development for commercial projects has been driven by DOER's

## COMMERCIAL BUILDING, PARTICULARLY LARGE OFFICE BUILDINGS, FACE UNIQUE CHALLENGES TO ACHIEVING NET ZERO ENERGY.

grant programs, but outside of these opportunities there has been more limited development. Commercial buildings, particularly large office buildings, face unique challenges to achieving net zero energy. Recent technology advancements and financial innovations are increasing the possibility of net zero and near net zero energy buildings within the Commonwealth.

This overview document will discuss the feasibility of commercial net zero energy buildings in Boston and explore options that encourage the construction of these facilities. Sections include:

- What Are Net Zero Energy Buildings?
- Common Barriers
- Aspiring to Zero: Next Steps and Policy Goals
- Conclusion
- Commercial Case Studies: Net Zero Energy and High Performance New Construction and Retrofit Projects

The document is based on a literature review and interviews with 12 local and national public, private, and non-profit organizations, including:

- Architecture 2030
- The Boston Society of Architects
- The City of Boston, Boston Planning and Development Agency
- The City of Cambridge
- Eversource Energy
- New Ecology
- MIT Investment Management Company
- National Grid
- The New Buildings Institute
- The Rocky Mountain Institute
- Skanska



## WHAT ARE NET ZERO ENERGY BUILDINGS?

Currently, practitioners and policy-makers do not have a consensus-based definition of net zero energy, near net zero energy, or energy positive buildings. The most commonly referenced definition was developed by the U.S. Department of Energy in 2015 (see Table 1).<sup>16</sup> Although the U.S. Department of Energy’s (DOE) and the Massachusetts DOER Zero Net Energy Buildings Task Force’s definitions emphasize the use of renewable energy on-site, many stakeholders interviewed for this project view off-site renewables as essential to achieving net zero energy in mid- to large-sized commercial properties in urban environments, given limited roof and open space.<sup>17</sup> Table 1 below highlights key definitional differences across major players.

Given the unique challenges of developing on-site renewables in dense urban environments and the high energy-use intensities of certain commercial spaces (such as hospitals and data centers), an emissions-based strategy may be more appropriate for establishing goals for cities like Boston. Emissions-based targets can be more feasible for existing facilities that have already made significant energy efficiency investments and/or have a mix of on- and off-site renewable power.<sup>22</sup> The City of Cambridge approaches net zero from a community-wide perspective using carbon emissions as the performance measure. Cambridge seeks to achieve community-wide net zero emissions, taking into consideration the collective performance of the city’s entire building portfolio.<sup>23</sup> This would allow emissions from energy-intensive buildings, such

as laboratories, to be offset by other buildings that are able to achieve net zero or energy positive status.

## NET ZERO EMISSIONS

Given the emphasis of the Cities of Boston and Cambridge on carbon emission reductions, this section will focus on net zero emissions in buildings, though similar strategies can be applied to achieve other net zero performance standards.

Net zero emissions can be achieved in commercial buildings through a mix of deep energy efficiency investments and on- and off-site renewables. As an initial step, buildings should reduce energy use as much as possible to minimize the need for on- or off-site renewable energy purchasing. Emerging technologies such as micro combined heat and power systems and battery energy storage can play a critical role in lowering on-site energy use and demand from the grid.

Achieving net zero energy or emissions performance targets across the commercial building stock will require both energy efficiency investments and increased access to renewable energy. There have been limited cases of commercial buildings achieving net zero emissions in cold-weather climates using on-site renewables, due to technical limitations of existing technology, costs, and the large space requirements for renewables to fully offset building energy use. For buildings to achieve net zero emissions on a large scale, the energy mix provided through electricity suppliers will have to include additional utility-scale renewable generation to achieve greenhouse gas targets. In the interim,

**TABLE 1: Net Zero, Near Net Zero, and Energy Positive Definitions**

NET ZERO ENERGY	NEAR NET ZERO ENERGY	ENERGY POSITIVE
<p><b>An energy efficient building which generates on-site renewable energy greater than the total amount consumed on-site.</b><sup>18</sup></p> <p>—U.S. Department of Energy</p>	<p><b>Buildings that may be designed to achieve one or more net zero definitions (e.g. net zero energy or emissions), but may not achieve a net zero energy in operations every year.</b><sup>19</sup></p> <p>—National Renewable Energy Laboratory</p>	<p><b>Produce more energy from renewables (on- or off-site) than needed for energy consumption.</b><sup>20</sup></p> <p>—Boston Planning and Development Agency</p>
<p><b>Note:</b> Some “net zero” definitions allow off-site renewable energy to be purchased to offset on-site use. The U.S. DOE refers to this as Renewable Energy Certificate—Zero Energy Building (REC-ZEB). Similarly, some definitions consider “net zero carbon” or “net zero emissions” rather than energy use for their performance standard. These standards typically allow for off-site generation.</p>	<p><b>Note:</b> There is no official federal definition of near net zero energy.</p>	<p><b>Note:</b> In practice, some facilities that designate themselves energy positive do not use all building energy loads in their calculations.<sup>21</sup></p>

buildings can reduce their emissions by ensuring that any off-site purchases provide additionality (i.e. ensuring a renewable energy purchase provides the financial security needed for development of a new project that would otherwise not move forward), or add renewables to local grids. A Better City's large scale power purchase agreement (PPA), which was facilitated among three of its members (Boston Medical Center, the Massachusetts Institute of Technology, and Post Office Square Redevelopment Corporation) in 2016, provides a successful example of such an off-site renewable energy arrangement.<sup>24</sup>

To achieve net zero emissions or net zero energy buildings at the scale necessary to hit the City and State's 2050 targets, most, if not all of the building stock in Boston will need to achieve net zero. Other cities will face similar challenges in meeting their 2030 and 2050 climate and energy goals.<sup>25</sup> While the Massachusetts building code will play an important role in increasing the energy performance of buildings over time, it does not currently include carbon performance targets, which would accelerate market movement. New York City set energy performance targets through its building code to achieve local emissions goals. These targets are scheduled to begin by 2019.<sup>26</sup> New York City is requiring air tightness testing and inspections, a 10% decrease in lighting power density over code, and modified energy calculations for commercial buildings. These changes are anticipated to increase energy savings 9% above the State's building code requirements.<sup>27</sup>

## COMMON BARRIERS

Mid-rise to high-rise net zero energy commercial facilities remain elusive in New England. This is due to challenges with achieving net zero energy and emissions at the commercial scale, including (1) feasibility, (2) additional costs, (3) operations and maintenance, and (4) perceptions.

1. **Feasibility** is a concern for buildings in dense urban areas with limited space for on-site renewables. Buildings with high energy use intensities (EUIs), such as offices over four-stories, laboratory space, hospitals, and server farms, struggle to generate adequate energy on-site, as required by some definitions of net zero energy. Shifting to emissions-based net zero definitions, which allow for both on- and off-site generation of energy, alleviates this challenge. However, some industry stakeholders worry that it could also incentivize projects to

purchase RECs, instead of first exhausting all available efficiency measures. Thus, there is a balance to strike in keeping the net zero definition sufficiently ambitious and achievable in the near term.

2. **High additional costs** for net zero emissions projects are a concern and barrier for developers who may have difficulty justifying the additional capital cost of including renewable technologies in their projects. This can be especially challenging when the developer does not plan to own the building over the long term. To date, uptake of net zero energy buildings in New England has been concentrated in owner-occupied buildings or mission-driven organizations which have less sensitivity to longer-term paybacks. A recent study conducted by Efficiency Vermont examined the cost comparison between net zero energy and near net zero energy of small commercial office spaces and buildings, and code-compliant construction.<sup>28</sup> In their analysis, net zero or near net zero construction proceeded at a cost premium of 6–16%, though operating and maintenance costs for the building were lower than for code-compliant construction. In contrast, during Seattle's Bullitt Center construction in 2013, costs were 23% more expensive than a building of similar characteristics (see Commercial Case Studies). These comparisons illustrate rapidly evolving cost dynamics. A recent study analyzing construction costs across a portfolio of office buildings indicate the market is moving toward achieving net zero and higher levels of LEED certification within normal cost parameters.<sup>29 30</sup>
3. **Operations and maintenance** of building equipment is critical for building performance, whether the facility is targeting net zero or near net zero emissions. The performance of some buildings in Boston and nationally differ substantially from energy models created during their design phases. Stakeholders highlighted the need for highly skilled workers to operate the equipment, and for continuous education of current building operators. Additionally, commercial tenants may have limited incentive to reduce their energy use unless they benefit directly. This gap can contribute to buildings underperforming due to increased plug loads or energy use in tenant spaces.
4. **Perceptions** impact developers' willingness to consider the feasibility of net zero energy buildings within the Northeast. Some of these



## **CITY, STATE, AND COMMERCIAL REAL ESTATE SECTOR LEADERS CAN PAVE A PATHWAY TOWARD NET ZERO EMISSIONS BY IMPROVING BUILDING ENERGY EFFICIENCY OPTIONS AND TRANSITIONING THE GRID TO A LOW-CARBON AND RENEWABLE ENERGY SUPPLY.**

perspectives do not consider the significant reductions in the cost of renewables, which impact the economics of both on- and off-site power purchases. There is also a perception that net zero emissions buildings are only possible in milder climates, such as California, where both the solar market and net zero markets are larger. While certain aspects of net zero energy buildings are easier to achieve in milder climates, several facilities in Massachusetts and buildings such as the EDGE Building and Powerhouse in Scandinavia (see Commercial Case Studies) demonstrate that project feasibility is increasing rapidly in cold-weather climates.

### **ASPIRING TO ZERO: NEXT STEPS AND POLICY GOALS**

City, State, and commercial real estate sector leaders can pave a pathway toward net zero emissions by improving building energy efficiency options and transitioning the grid to a low-carbon and renewable energy supply. It is crucial to aspire towards net zero emissions across the city, and establish interim, achievable targets to overcome barriers and move the industry forward (see Table 2).

The Commonwealth's 2009 Zero Net Energy Buildings Task Force report, "Getting to Zero," provides a suite of recommendations for the commercial building sector, including: shifting to performance-based standards for building energy use; improving the building code's prescriptive requirements around energy use and efficiency; requiring "solar-readiness"; and requiring electricity sub-metering for new construction and major renovations.<sup>31</sup> The City of Cambridge recently released their "Getting to Net Zero Framework" which proposes key actions for the City to improve the energy efficiency of existing buildings via retrofit programs, energy management plans, and retrocommissioning during renovation or at the point of sale.<sup>32</sup> Further, the Cambridge framework recommends net zero emissions targets for new construction and related incentives, and policies for shifting the city's energy supply to low-carbon and renewable energy.

The section below acknowledges the existing recommendations above and outlines actions that can be taken by the City of Boston, the commercial real estate sector, the utilities, and A Better City. A Better City is committed to encouraging its members to incorporate net zero emissions strategies into their facilities, aligned with the City's goal to eliminate carbon emissions by 2050. By necessity, the building stock must include a mix of high-performance, net zero and energy positive facilities. Advancing these actions over the next five to seven years provides the foundation for the City of Boston to set appropriate net zero emissions targets as part of the their interim 2030 climate goals.



**TABLE 2: Policy Options for Encouraging Net Zero Buildings**

PRIMARY ACTOR(S)	CITY OF BOSTON	UTILITIES	A BETTER CITY
<b>Near Term (1–2 Years)</b>			
<p><b>Continue to adopt State stretch energy code updates</b></p> <p>The City's adoption of the State's stretch energy code and its recent inclusion of LEED v4 requirements for new construction as part of Article 37 of the zoning code continue to improve energy efficiency in new commercial buildings and major retrofits. However, in order to achieve net zero emissions over the long term, the pace of the building code improvements will need to increase.<sup>33</sup></p>	●		
<p><b>Clarify and expand energy action requirements in BERDO</b></p> <p>Currently, reporting properties under Boston's Building Energy Reporting and Disclosure Ordinance (BERDO) must demonstrate energy efficiency improvement or complete one of a number of energy actions within five years. The City could offer guidance and technical assistance to help buildings implement appropriate actions, including long-term energy planning for large commercial buildings.</p>	●		
<p><b>Explore the feasibility and use of district energy and microgrid systems</b></p> <p>Leveraging the results of the Boston Community Energy Study, the City could explore emissions reduction options across a network of buildings by encouraging district energy or microgrid systems using low-carbon or renewable sources. The City could provide regulatory and legal guidance and funding support, where applicable.<sup>34</sup></p>	●	●	
<p><b>Encourage training for building energy managers to enable high-performance buildings to operate at maximum efficiency</b></p> <p>Building owners and developers have identified a gap between high-performance building systems and the availability of skilled building operators. A Better City and its members could work with the Green Ribbon Commission's Higher Education Working Group, Eversource Energy, and others to encourage training programs at local community colleges that connect new trainees to jobs in Boston.</p>		●	●
<p><b>Encourage building participation in utility demand management pilots for large and small commercial buildings</b></p> <p>Utilities are developing demand management pilot programs for the commercial sector. A Better City will encourage members to participate. These pilot programs include measures such as energy storage, which may assist in helping on-site renewables better serve building energy needs. Customer-sited demand management programs, which compensate building owners for reducing energy use during peak periods on the grid, could serve to encourage landlords and tenants to collaborate and discuss occupant behavior and building energy use.</p>		●	●

**TABLE 2: Policy Options for Encouraging Net Zero Buildings** (continued)

PRIMARY ACTOR(S)	CITY OF BOSTON	UTILITIES	A BETTER CITY
<p><b>Increase supply and use of renewable energy sources</b></p> <p>A Better City will continue to facilitate the use of large-scale PPAs to procure renewable energy for the commercial sector in Boston, by providing information and encouraging members to participate. Integrating storage with on-site renewables could also assist in managing building energy loads.</p>			●
<p><b>Incorporate the commercial sector into the E+ or a similar incentive program</b></p> <p>The City could encourage demonstrations of net zero or near net zero emissions projects by including the commercial buildings in the City's E+ Green Building Program or including the commercial sector in the City's land disposition process, to lower some of the upfront costs to developing a net zero energy building.<sup>95</sup></p>	●		
<b>Medium Term (3–5 Years)</b>			
<p><b>Develop utility demand management programs for market participation</b></p> <p>Building on lessons from pilot programs currently in design and scheduled through 2018, Eversource Energy and other Massachusetts utilities are developing broader programs to offer demand response tools and training to the commercial real estate sector (e.g. battery storage, software and controls, and active demand response).</p>		●	
<p><b>Pilot height and density incentives to encourage net zero energy construction</b></p> <p>The Boston Planning &amp; Development Authority could explore development incentives that encourage developers to pursue net zero or near net zero energy buildings. These could include height and density bonuses such as increasing the allowable floor area ratio or waiving certain taxes or fees. The added incentives may encourage developers to explore additional design strategies and the integration of efficiency and clean energy technologies into their projects.</p>	●		
<p><b>Offer expanded technical assistance for deeper efficiency retrofits or vouchers for design assistance for near net zero energy buildings</b></p> <p>To meet its energy efficiency obligations, the utilities could offer technical assistance resources to the commercial real estate sector to encourage high-performance buildings and net zero emissions buildings.</p>		●	
<p><b>Continue and expand the Renew Boston Trust program to commercial facilities</b></p> <p>The City could continue to demonstrate leadership in energy efficiency via its Renew Boston Trust program and energy efficiency initiatives for non-profit buildings, by expanding these opportunities for energy efficiency retrofit financing to commercial buildings.</p>	●		

— CONTINUED —

**TO MEET ITS ENERGY EFFICIENCY OBLIGATIONS, THE UTILITIES COULD OFFER TECHNICAL ASSISTANCE RESOURCES TO THE COMMERCIAL REAL ESTATE SECTOR TO ENCOURAGE HIGH-PERFORMANCE BUILDINGS AND NET ZERO EMISSIONS BUILDINGS.**

**TABLE 2: Policy Options for Encouraging Net Zero Buildings** (continued)

PRIMARY ACTOR(S)	CITY OF BOSTON	UTILITIES	A BETTER CITY
<p><b>Implement and continue grid modernization efforts</b></p> <p>To support the integration of renewables and distributed technology across the utility network, the program administrators should stay committed to continued grid upgrades that are proactive and responsive to grid interconnection needs for current and future technologies.</p>		●	
<p><b>Examine code reform to integrate carbon as well as energy saving targets into performance expectations for buildings</b></p> <p>A Better City could conduct research into effective performance-based building code options for Boston that factor emissions reduction into performance measures. This research could observe the results and impacts of code changes in New York City.</p>	●		●
<b>Long Term (5+ Years)</b>			
<p><b>Support emerging renewable aggregation options</b></p> <p>To increase the accessibility of renewables, utility program administrators could explore supporting Community Choice Aggregation efforts or develop their own cost-competitive green tariff programs to increase access to lower-carbon electricity for additional businesses. In California, Pacific Gas and Electric has served as a partner to an increasing number of community choice aggregations over the past several years by guiding implementation, facilitating on-bill notifications regarding program participation and easing the rollout of community-wide programs.<sup>36</sup></p>	●	●	
<p><b>Continue to pursue ambitious energy efficiency targets in the next three-year planning cycle (2019–2021) for the EEAC</b></p> <p>A Better City will continue to represent the commercial real estate sector at the Massachusetts Energy Efficiency Advisory Council (EEAC) meetings and encourage the development of demand response programs and additional energy efficiency incentives for the commercial real estate sector.</p>		●	●

## CONCLUSION

The next few decades will be crucial to achieving emissions reductions that ensure a lower carbon trajectory and minimize potentially devastating climate change impacts in Boston, including sea level rise, increased precipitation, and rising temperatures. Important interim steps, such as the policy pathways outlined above, and increased investments in energy efficiency and renewable energy can maintain momentum and long-term cost savings for the commercial real estate sector. A Better City, in partnership with the Green Ribbon Commission, is committed to providing resources and sparking conversations to encourage innovation in new and existing building projects, beginning with

a dialogue on net zero energy buildings in May 2017. The City of Boston is also committed to exploring pathways for achieving its 100% GHG emissions reduction target within its building sector with other cities in the Carbon Neutral Cities Alliance. Next steps, such as providing zoning guidance and incentives to the commercial sector, will be necessary to transform the building stock. The commercial buildings market will continue to evolve and innovate. Through collaboration between the public and private sectors, the City of Boston can encourage innovation and higher performing buildings by establishing ambitious net zero emissions performance standards by 2030. These advancements will make significant progress towards the City’s Carbon Free vision.

# COMMERCIAL CASE STUDIES

## NET ZERO ENERGY AND HIGH PERFORMANCE NEW CONSTRUCTION AND RETROFIT PROJECTS

The buildings presented in the case studies below have creatively leveraged a mix of on-site and off-site renewable energy, external and internal policy goals, and funding, to successfully pursue net zero energy facilities in cold-weather climates.

- 888 Boylston Street
- Boston Medical Center
- Bristol Community College John J. Sbrega Health and Science Building
- Bullitt Center
- Castle Square Apartments
- John W. Olver Transit Center
- Partners Healthcare in Assembly Row
- Powerhouse Kjørbo



## 888 BOYLSTON STREET

### HIGH-PERFORMANCE OFFICE BUILDING IN BOSTON



#### Location

Boston, MA

#### Completion Date

2016

#### Building Type

Mixed Use - office and retail

#### Certifications & Awards

LEED Platinum (certification in progress)  
IALD Lighting Design Awards, Award of Merit + Sustainability

### BUILDING SUMMARY

The construction of this 17-story mixed-use building at 888 Boylston Street in Boston, MA filled the last remaining open space at the Prudential Center. It is a retail, dining, and commercial complex, which first began development in the 1960s. The facility was designed to consume 47% less energy and cut water use by 37% compared to similar office buildings. The building was also designed to reduce lighting needs by 60%.<sup>51</sup> Natural light will cover over 95% of 888 Boylston's interior floor space. The construction costs for the facility were \$275 million (\$651/square foot).

### FEATURES

The high-performance envelope of the building includes an all-glass exterior to limit the need for synthetic lighting and a green roof that hosts bee colonies. The building features solar photovoltaic (PV) panels (107 kW) and 14 vertical-axis wind turbines (14 kW). These on-site renewables will power all exterior building and plaza lighting. LED lighting and a high-efficiency chilled beam HVAC system also play a role in the building's low energy use intensity (EUI). In addition to these existing features, cogeneration and ground source heat exchangers were considered, but were determined not to be economically advisable at the time.<sup>52</sup> Critical mechanical and electrical equipment has been raised in the building to improve the building's resiliency to natural disasters and climate change.<sup>53</sup>

### SUCCESS DRIVERS

The building, designed by FXFWOLE and developed by Boston Properties, is anticipated to have the lowest EUI in Boston (40 kBtu/square foot) and to be one of the highest performing office buildings in New England. This environmentally focused and energy-centric building design was a means to enhance tenant and shopper experience and allow for office planning flexibility.

## BOSTON MEDICAL CENTER

### BOSTON'S GREENEST HOSPITAL



#### Location

Boston, MA

Completion Date  
2018

#### Building Type

Hospital campus

#### Certifications & Awards

Carbon neutral (2018)

### BUILDING SUMMARY

Starting in 2015, Boston Medical Center (BMC) spent \$350 million to redesign its campus, merging the Boston City Hospital and University Hospital locations.<sup>59</sup> This move shrunk the campus' footprint by 400,000 square feet and is expected to save BMC \$25 million annually on energy and operating costs. Select departments and buildings will be expanded, while others are consolidated.<sup>60</sup>

### FEATURES

The campus made a series of HVAC upgrades between 2011 and 2015 reducing emissions by 20%. The campus also signed a three-year Memorandum of Understanding with Eversource Energy in 2015 to maximize and partner on energy efficiency upgrades. The campus also utilizes Veolia's district steam supplied by a combined heat and power plant generating "green steam" for building heating needs. In 2016, BMC worked with A Better City to enter into a collaborative solar power purchase agreement to cover 100% of its electricity usage.<sup>61</sup> In 2017, BMC unveiled its new cogeneration plant to provide greater resiliency as well as cheaper and cleaner energy. Upon completion of the campus redesign in 2018, BMC expects to be carbon neutral.

### SUCCESS DRIVERS

BMC is part of the Healthier Hospitals Leaner Energy Challenge, and places a strong emphasis on connecting sustainability with health outcomes. With a long history as New England's largest safety-net hospital, keeping its community healthy has been a primary focus of BMC long before national healthcare reform. Given this, supporting a healthy environment has been a natural extension of BMC's efforts to make the City of Boston the healthiest urban population in the world.

## BRISTOL COMMUNITY COLLEGE JOHN J. SBREGA HEALTH AND SCIENCE BUILDING

### NET ZERO ENERGY CAMPUS LABORATORY



#### Location

Fall River, MA

#### Completion Date

2016

#### Building Type

Campus laboratory, medical

#### Certifications and Awards

LEED Platinum

MA DOER Leading by Example Award, 2014

ASHRAE Region 1 Award for Engineering Excellence, 2014

NACUBO Innovation Award, 2015

MA DOER Renewable Energy Grant, 2015

MA DOER Pathways to Net Zero Energy Grant, 2015

12SL Go Beyond Award, 2016

### BUILDING SUMMARY

The John J. Sbraga Health and Science Building is a net zero laboratory and classroom space at Bristol Community College in Fall River, MA. At 50,600 square feet, this two-story building is the largest net zero energy classroom and lab space in the Northeast.<sup>37</sup> The Sbraga Building was initially designed as a high performance LEED Silver building. However, the building's energy use would have utilized over half of the energy from a planned 3.2MW ground-mounted PV system. To counter this, a net zero energy design was also developed. A detailed side-by-side cost comparison showed a \$200,000 savings in construction costs for the net zero energy option.<sup>38</sup> The final construction cost of the building was \$29.5M (\$582 per square foot), which is in line with typical non-net zero energy teaching lab buildings.

### FEATURES

The building was engineered by BR+A and designed by Sasaki Associates. It features a hybrid air source/ground source heat pump, solar hot water system, on-site solar photovoltaics, LED lighting, filtered ductless fume hoods that permit air recirculation, and a heat recovery wheel in the HVAC system.<sup>39</sup> These features, coupled with a high-performance building envelope, resulted in an approximately 80% reduction in the building's EUI as compared to similar buildings (55 kBtu/square foot /year).<sup>40</sup> Solar energy generation covers all of the remaining energy needs for the building. An enhanced monitoring and verification system is also in place to monitor building performance.

### SUCCESS DRIVERS

The drivers behind pursuing net zero were the campus' 2050 carbon neutrality goal and the Massachusetts LEED Silver requirement for public buildings.

## BULLITT CENTER

### COMMERCIAL BUILDING WITH MINIMAL ENVIRONMENTAL FOOTPRINT



#### Location

Seattle, WA

#### Completion Date

2013

#### Building Type

Commercial

#### Certifications & Awards

Living Building Certification  
Sustainable Building of the Year, World  
Architecture News, 2013

### BUILDING SUMMARY

The Bullitt Center in Seattle, WA was designed to have nearly no environmental footprint. Developers estimate that the \$32.5 million project cost 23% more than a typical Class-A office building in Seattle.<sup>62</sup> The Bullitt Foundation, which is headquartered in the building, attributes this increase largely to the “soft costs” of implementing unprecedented infrastructure. Current rents are comparable for new LEED-certified construction in Seattle, and the building is currently cash-flow positive.<sup>63</sup> The Center uses 2-3% of its energy for heating and cooling and produced 60% more electricity than needed by its tenants and operations in its first year.<sup>64</sup>

### FEATURES

The building includes an array of features, including a high-performance envelope, green roof, rooftop solar PV system, a regenerative elevator, heat recovery ventilation, automated daylight management system, and composting toilets. It has efficient windows that will open and close automatically to manage temperature and ground source heat pumps that supply heating, cooling, and warm water.<sup>65</sup>

### SUCCESS DRIVERS

The building aims to show the feasibility of net zero energy, water, and waste, and accelerate the uptake of similar design principles in other buildings. The Bullitt Foundation released guides and case studies to facilitate these design transitions elsewhere.<sup>66</sup>

## CASTLE SQUARE APARTMENTS

### DEEP ENERGY RETROFIT OF HOUSING



<b>Location</b>	Boston, MA
<b>Completion Date</b>	2012
<b>Building Type</b>	Multifamily housing
<b>Certifications &amp; Awards</b>	LEED Platinum Multiple federal, state and foundation grants

### BUILDING SUMMARY

In 2011, 308 of the 500 Castle Square Apartments in Boston, MA received energy efficiency upgrades. One hundred ninety-two of the apartments underwent deep energy retrofits, reducing energy use by 72% in those units. At the time, it was the largest deep energy retrofit project of its kind undertaken in the U.S.<sup>54</sup> Across the entire complex, the project reduced energy use by 36%. The complex was originally constructed in the 1960s as affordable housing with minimal insulation and few efficiency measures. The Better Buildings Initiative reported that the complex receives annual energy cost savings of \$213,000 after the retrofit. The retrofits cost roughly \$42,000 per apartment.<sup>55</sup>

### FEATURES

Owned by the Castle Square Tenants Organization, in partnership with WinnCompanies, the building envelope now includes efficient windows and doors and extensive sealing. An insulation shell was constructed directly on the outside of the building, eliminating the need to gut apartments. For this reason, residents were not displaced during construction and were provided hospitality quarters when work was underway within their units. The site features four solar hot water systems, LED and CFL lighting, as well as high-efficiency refrigerators, air conditioners, and boilers.<sup>56</sup>

### SUCCESS DRIVERS

The residents who rent the units had high energy bills and were a driving force in encouraging the retrofit. The project resulted in a “how-to” guide and can be used as an example of effective deep energy retrofits for low- to moderate-income housing without displacing residents.<sup>57</sup> The project received grant funding from a variety of federal, state, non-profit, and for-profit entities.<sup>58</sup>

## JOHN W. OLVER TRANSIT CENTER

### FIRST NET ZERO ENERGY TRANSIT CENTER IN THE U.S.



#### Location

Greenfield, MA

#### Completion Date

2012

#### Building Type

Office, transit hub

#### Certifications and Awards

American Council of Engineering Companies, Gold  
 American Institute of Architects  
 New England, Merit Award for Design Excellence, 2014  
 Boston Society of Architects, Design Award, 2012  
 Chicago Athenaeum, American Architecture Award, 2014  
 Society of American Registered Architects  
 New York, Design Excellence Award, 2014

### BUILDING SUMMARY

The John W. Olver Transit Center in Greenfield, MA, is the first net zero energy transit center in the U.S.<sup>44</sup> It is a two-story, 24,000-square-foot office building housing the Franklin Regional Transit Authority and servicing both bus and train lines. The building contains offices, community space, a waiting area, a café, storage, and rest-rooms. The total building cost was just under \$11 million (\$454/square foot).

### FEATURES

Designed by Charles Rose Architects, the building's envelope was designed to minimize lighting, heating, and cooling needs, and consists of glazed windows and a solar wall. The solar wall can preheat air by as much as 15 degrees Fahrenheit during the winter months. In addition, the site features both ground-source heat pumps and an on-site wood pellet boiler, a 98kW ground-mounted solar PV array, LED lighting, chilled beam air conditioning, and an energy recovery air handling unit.<sup>45</sup> The annual energy consumption is estimated to be less than 35 kBtu/square foot.

### SUCCESS DRIVERS

The construction was inspired by the 2015 Presidential Executive Order 13514, which required all new federal buildings to achieve net zero by 2030.<sup>46</sup> The Center was a joint project of MassDOT, the Massachusetts Recovery and Reinvestment Office, and the MBTA. The initial project goals were to design and construct a building that was net zero, energy efficient, user friendly, and 75% daylight autonomous, and that would optimize capital and operational costs. The project received additional funding through a grant via the American Recovery and Reinvestment Act.

## PARTNERS HEALTHCARE IN ASSEMBLY ROW

### HEADQUARTERS OF LARGEST EMPLOYER IN MA



<b>Location</b>	Somerville, MA
<b>Completion Date</b>	2016
<b>Building Type</b>	Mixed use—office with ground and second-level retail
<b>Certifications &amp; Awards</b>	LEED v4 Gold (certification in progress) 100% non-carbon electricity sources

### BUILDING SUMMARY

Partners Healthcare, a not-for-profit health care system and the largest employer in Massachusetts, determined that it could consolidate support offices from 13 locations into a single building and lower operating costs. The result is a new 13-story, 901,000-square-foot building in Somerville, MA, located next to the new Assembly Row transit station.<sup>47</sup> The construction of the building, which cost \$290 million (\$325/square foot), began in 2014 and the organization started moving the first of 4,300 employees in May of 2016.<sup>48</sup>

### FEATURES

Designed by Gensler, the building's envelope includes energy-efficient walls and windows, as well as a green roof to reduce the urban heat island effect and support stormwater management. The building features LED lighting, a high-efficiency underfloor air distribution system, destination response elevators, narrow floorplates with no private offices to improve access to natural daylight, and outdoor balconies that employees can access year round. Recognizing the potential for future flooding, the ground floor and critical systems are raised above predicted flood elevations, including a 13.8Mv substation. A 1.1 MW solar installation on the garage generates 14% of the building's annual energy use. The building is designed to operate at 54 kBtu/square foot and is projected to use 22% less energy than a comparable building, placing the newly constructed facility in the top 5% of office buildings in the Northeast.<sup>49</sup>

### SUCCESS DRIVERS

By having a single administrative campus, Partners HealthCare aims to improve operational efficiency across offices, reduce leasing costs, lower energy costs, and improve employee access and commuting patterns. This transition is projected to save Partners \$12 to \$15 million dollars annually.<sup>50</sup>

## POWERHOUSE KJØRBO

### ENERGY POSITIVE COMMERCIAL RETROFIT



#### Location

Sandvika, Norway

#### Completion Date

2014

#### Building Type

Commercial office

#### Certifications and Awards

BREEAM-NOR Certification 'Outstanding'

Norwegian Passive House

Nominated MIPIM "Best Innovative Green Building, 2015

Nominated Norwegian Technology Award, 2014

### BUILDING SUMMARY

The Powerhouse Kjørbo is the world's northernmost energy positive commercial office building.<sup>41</sup> The building is located in Sandvika, Norway, which has a cold-weather climate similar to that of Boston. The complex was originally constructed in 1980 and contains two four-story buildings with a combined area of approximately 56,000 square feet. The buildings' energy use decreased by 90% after renovation, and the facility will be energy positive over its anticipated life. In total, the buildings' construction cost was €13.8 million (U.S. \$14.6 million; \$236/square foot).

### FEATURES

The buildings, designed by Snøhetta, each have an envelope of highly-insulated timber frame walls, triple-glazed windows, and a high degree of air tightness. The site features an automated exterior sunscreen, demand-controlled lighting, rooftop solar panels, geothermal heat pumps, and an innovative central staircase that doubles as a ventilation shaft.<sup>42</sup> The on-site solar installation and geothermal heat pumps are designed to cover 100% of the buildings' electrical, heating, cooling, and hot water needs. It is also connected to a district heating system in case additional power is needed. The 311 kW solar system is expected to generate 18.4 kWh/m<sup>2</sup> beyond load each year.<sup>43</sup>

### SUCCESS DRIVERS

The renovation's purpose was to demonstrate the potential for transforming older office buildings into net positive buildings. The effort was led by the Powerhouse Consortium, a group of partnering architecture, design, construction, and environmental organizations that aim to demonstrate the economic and environmental viability of energy positive commercial buildings in colder climates.

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