Zero Net Carbon Building Zoning Initiative

Final Report

bpda

Cover Image: Three Eighty Stuart - Skanska USA, CBT Architects

Contents

Dear Neighbor, Here in Boston, the effects of climate change are a part of our everyday life. Rising sea levels, stronger storms, and hotter days all pose serious threats to critical infrastructure and our communities. This summer, Boston experienced its three hottest weeks on record. The heat waves we've already experienced and those to come are, in part, the result of our carbon emissions. And 70% of Boston's emissions come from our buildings. That's why we're taking bold action to achieve carbon neutrality by 2050 through our Zero Net Carbon Building Zoning Initiative.

The Zero Net Carbon Building Zoning Initiative proposes zoning policies that will help steer Boston toward a carbon neutral future. Every new development in our city—whether it's affordable housing, commercial offices, lab or life science spaces—is an opportunity to implement our zero net carbon building framework.

The recommendations included in this report are the culmination of nearly two years of research and analysis, public and technical advisory meetings, and ongoing stakeholder engagement. I'm grateful to everyone who contributed to the creation of this report, from residents and local organizations to community climate activists and building professionals.

Our national standing as a leader in sustainable development is a testament to the commitment and vision of our local leaders. The model presented in this report serves as a blueprint for the rest of the nation—and is proof of what is possible when we work in community to tackle our most pressing challenges.

This initiative ensures that large, new buildings in Boston don't come at the cost of our future. But making Boston a Green New Deal city means that we also need to address our existing buildings—which will make up 85% of our total building footprint by 2050. That's why, last year, we passed the Building Emissions Reductions and Disclosure Ordinance (BERDO), establishing a clear timeline to retrofit existing buildings in Boston. This initiative complements BERDO seamlessly, ensuring that our growth empowers us to build a greener, healthier, more equitable future for all of us.

In service,

Michelle Wu

Michelle Wu
Mayor of Boston

The Kenzie, Bartlett Station - POAH/Nuestra, DREAM Collaborative Architects

Key Action Items

Since its enactment in 2007, Boston's Green Building zoning has contributed to the transformation of building practices in the City and beyond. The buildings of today typically achieve LEED Gold or better. These projects include strategies to reduce heat island sources, storm water discharge, water use, and carbon dioxide emissions. They generate energy onsite and use clean, renewable electricity.

As a national leader in innovation and sustainable development, Boston has set goals to be carbon neutral by 2050. The Carbon Free Boston Report and the 2019 Climate Action Plan Update, respectively, identify strategies and specific policy actions for Boston to achieve carbon neutrality. The analysis denotes buildings as Boston's largest source of community carbon emissions and recommends decarbonizing new building construction.

In response, the City launched the Zero Net Carbon Building Zoning Initiative. Working with building practice leaders and stakeholders, the BPDA convened public and Technical Advisory Groups meetings resulting in recommendations for updating Boston's existing Article 37 Green Building zoning.

These recommendations include three key updates to the current zoning:

- Lower the applicability threshold to buildings 20,000 square feet and larger;
- Raise the minimum LEED score to Gold or better; and
- Add a zero net carbon building standard that prioritizes low carbon building construction and generation and use of clean renewable energy.

In support of the proposed updates, the BPDA has developed supporting Green Building Policies and Standards and will convene a Green Building Advisory Committee to assist in the maintaining, updating, and advancing of these policies and standards.

Community Engagement and Planning Process

The climate is changing before our eyes, and we are seeing the impacts now. Global temperatures are rising, driven by the unprecedented accumulation of greenhouse gases, and the effects on Boston are undeniable: rising sea levels, record high temperatures, and extreme weather. Recognizing our unique vulnerabilities and opportunities, Boston is forging a path to slash our carbon emissions now and achieve carbon neutrality by 2050.

Working with community advocates, stakeholders, and building practice leaders the City, BPDA, and a team of building experts hosted a series of public meetings, organized four Technical Advisory Groups (TAGs), and conducted an extensive series of stakeholder, advocate, and local community engagement meetings. In total, between September 2020 and January 2022, the City and its partners convened 3 broad public meetings, 15 TAG meetings, and over 25 stakeholder and community meetings.

The four TAGs were tasked with assessing industry best practices and recommending specific strategies and actions for reducing carbon emissions with the following focuses:

- Embodied Carbon Reduction
- Low Carbon Buildings
- On-site Renewable Energy
- Renewable Energy Procurement

The City greatly appreciates the work of the numerous individuals, professions, organizations, and consultants who contributed to the research, analysis, and discussions and assisted in preparing these recommendations.

Building Spotlight

Landmark Center, Fenway

ZNC Life Science Lab/Office

- LEED Gold
- 53% Energy Savings
- pCEI of 6.17 kg CO_2e/sf-year
- 93% Reduction in fossil fuel use
- 100% renewable electricity

Summary of Recommendations


1B1227 TOP
C20-342
1B1227 N/P

Rendering Three Eighty Stuart - Skanska USA, CBT Architects

Summary Of Recommendations

The following recommendations are for the BPDA and City of Boston to implement in order to implement a zero net carbon zoning ordinance and advance sustainable building practices in Boston. These recommendations are envisioned as updates to the existing Article 37 review process and would be enacted as an amendment of the existing zoning. The existing Article 37 three phase review process (Initial Filing, Design Filing, Construction Filing) would not change.

A new zero net carbon (ZNC) emissions framework and standards are proposed that prioritize minimizing carbon emissions from new building construction and operation, maximizing on-site renewable energy generation, and procuring renewable energy sufficient to annually achieve zero net carbon emissions.

Throughout the ZNC planning process, practice leaders in real estate development, building design, and construction have adopted the proposed framework and proven that ZNC buildings can be built on budget and at all scales, from the smallest house to the largest lab building. The City especially wants to recognize the efforts of the affordable housing development teams who are creating the next generation of high-performance housing and regularly exceed the low carbon performance targets.

These policies reflect the critical importance of partnership with the communities where new buildings are being constructed and with the practice leaders planning, designing, developing, and constructing our built environment. They also recognize and seek to inspire innovation and diversity throughout the building work spaces.

Applicability Threshold

All new buildings greater than 20,000 square feet in size or that contain 15 or more housing units will be required to comply with Article 37. Previously, only projects greater than 50,000 sf were subject to Article 37 review. Article 37 is part of the large building review process and examines a project's carbon footprint and emissions. These thresholds

fully align Zoning Article 37 with the Zoning Article 80 Review framework and the recently updated Building Emissions Reduction and Disclosure Ordinance (BERDO). Expanding the number of projects that undergo Article 37 review will result in the construction of more sustainable buildings and reduce adverse environmental impacts across the City. The lower threshold will also better align with green building standards across the country.

Minimum LEED Outcome

The minimum LEED score for new construction has been raised from LEED Certified (40+ points) to LEED Gold (60+ points). The US Green Building Council's Leadership in Environmental and Energy Design (LEED) Rating Systems provide comprehensive standards for sustainable building development and management practices that are globally recognized and have proven market value.

Zero Net Carbon Emissions Framework

Add a practice framework and standards that prioritize 1) minimizing carbon emissions from new building construction and operation, 2) maximizing on-site renewable energy generation, and 3) procuring renewable energy, and that integrate with the Boston Emission Reduction and Disclosure Ordinance.

Advisory Committee

The BPDA will organize a Green Building Advisory Committee consisting of community and professional representatives, stakeholders, and building experts. The Committee will assist the BPDA and the City in maintaining, updating, and advancing the related policies and standards.

Key Definitions

(A full list of terms used in this document is included in the glossary)

Article 37: Green Buildings and Climate Resiliency Review Procedures

This section of the Boston Zoning Code states that all projects subject to Article 80 Large Project Review are planned, designed, constructed, and managed to minimize adverse environmental impacts; conserve natural resources; are resilient to climate change; promote a more sustainable city; and enhance the quality of life in Boston.

Embodied Carbon

Building Spotlight

Boston University Data Sciences Center

Computing & Data Sciences
ZNC Institution

- LEED Platinum
- 34% Energy Savings
- pCEI of 2.9 kg CO_2e/sf-year
- 964 kW of Solar PV on campus
- 100% renewable electricity

Key Recommendations

- Introduce standards and requirements for whole building life cycle assessment (LCA) reports;
- Identify and require achievement of LEED embodied carbon reduction credits;
- Develop strategies to reduce, reuse and recycle building demolition and construction waste;
- Advance industry carbon accounting and embodied carbon reduction practices; and
- Pilot new low embodied carbon practices and support innovations.

The first opportunity to reduce carbon dioxide and greenhouse gas emissions in the life cycle of a building is in its initial construction. These emissions, referred to as embodied carbon, contribute a substantial amount of a building's emissions throughout its entire life – in a new high-performance building, the construction emissions alone can account for half of its carbon emissions for the first 20 years.

With industry practices related to reducing embodied carbon still emerging, the City's efforts should be to encourage this growth. This effort should include an emphasis on embodied carbon reduction in Boston's next Climate Action Plan update and establishing a zero-net embodied carbon standard (ZNEC) for all new construction.

The first strategy to reduce embodied carbon is through the reuse and recycling of building decommissioning, demolition, and construction waste. This can be broken down into several steps:

- Identify barriers to building component and material reuse;
- Evaluate opportunities to support local businesses that focus on material salvaging;
- Support workforce development in retrofitting existing buildings and salvaging/reinstalling components;
- Include the embodied carbon of building demolition in carbon emission targets and account for avoided carbon emissions from reuse and recycling as a credit;

- Participate in the City of Boston's Deconstruction Pilot; and
- Support implementation of a Boston zero waste policy.

Buildings should be required to achieve specific LEED credits related to reducing embodied carbon and advancing industry practices. These credits include Building Life-Cycle Impact Reduction, the Building Product Disclosure and Optimization (EPDs and Sourcing of Raw Materials), and Procurement of Low Carbon Construction Materials.

Project filings should include a whole building LCA report identifying hot spots of embodied carbon and reduction alternatives. Certain projects could be required to meet local/regional building embodied carbon intensity targets depending on building type.

The City and BPDA should also strive to do the following:

- Partner with local organizations to support regular convening of public officials and stakeholders and ensure policy alignment;
- Launch pilot programs to understand and accelerate promising new practices;
- Encourage innovation and best practices through the spotlighting of case studies;
- Increase city staff's ability to quickly respond to and process building proposals and filings;
- Provide resources and education to ensure staff are up to date on best practices for reducing embodied carbon;
- Assess and expand workforce capacity and assist businesses in realizing new opportunities related to embodied carbon reduction while supporting Boston's diversity, equity and inclusion goals;
- Create and support workforce training and education programs, including collaboration opportunities with local industries and professional associations;
- Update City policies to incorporate potential structural, regulatory and financial incentives of embodied carbon-conscious practices;
- Establish a professional expert advisory committee on embodied carbon policy and program development with a defined purpose, engagement and work plan, and schedule; and
- Integrate Boston's diversity, equity and inclusion goals and include stakeholder engagement and policy actions.

Key Definitions

(A full list of terms used in this document is included in the glossary)

Life Cycle Assessment (LCA)
This is an analysis of the total amount of carbon dioxide emitted throughout the course of a product's life. It includes raw materials and extraction, manufacture, transportation, usage, and destruction.

Embodied carbon
Embodied carbon is the amount of carbon dioxide that was emitted during the construction of the building. This includes manufacturing, transportation, installation, maintenance, and disposal of materials.

Environmental Product Declaration (EPD)
An Environmental Product Declaration (EPD) is a report from a product's manufacturer. It is a life cycle assessment (LCA) on the product and analyzes how much carbon dioxide was released at every step of the product's creation.

Low Carbon Building

Key Recommendations

- Establish two building carbon emission performance targets with corresponding compliance pathways:
- For any building use, based on comparative performance modeling, set a target of 40% reduction in carbon emissions (or 30% for hospitals);
- Set predictive Carbon Emission Intensity (pCEI) targets, based on performance modeling, for each building use; and
- Identify and require specific LEED credits that support reduction in operational carbon, greenhouse gas emissions, and refrigerants with high global warming potential.

Operational carbon emissions are the greenhouse gases emitted from our use and occupancy of buildings. These include the emissions for the electricity used for heating, cooling, lighting and appliances plugged into outlets as well as any on-site fossil fuel use. In the last few years, new practices and products have enabled significant reductions in building operational carbon emissions. Practices as simple as switching to efficient electric HVAC systems, adding energy recovery ventilation, and improving building enclosures are driving down carbon emissions and, with state and utility incentives, can be done at no added cost.

The two target types are recommended to ensure all projects can establish compliance pathways for cost-effective low-carbon building practices. Both pathways utilize current building planning and predictive modeling tools and reference standards that can rise as tools and standards evolve. In consultation with industry experts, carbon emissions targets and specifics should be updated regularly.

Comparative Reduction in Carbon Emissions

Professional standards including the American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) 90.1 define criteria for building performance modeling and base case building performance conditions. By comparing the modeled performance of a "base case" building that only meets minimum code requirements to that of the proposed design, building professionals can calculate and predict operational carbon emissions and evaluate strategies for reducing them. An analysis of recent building practices indicates new buildings can reasonably achieve a 40% or greater reduction (except 30% for hospitals) of carbon emissions.

Building Use Specific Carbon Emission Intensity

Some types of buildings have very consistent predicted carbon emissions from one project to another. For these types, a metric of carbon emissions per square foot provides a simpler and more effective indicator. This is referred to as a predictive Carbon Emission Intensity (pCEI) and is measured in kilograms of Carbon Dioxide Equivalents per square foot of building area emitted yearly (kg CO_2e/sf-yr). Reflecting the same 40% or greater reduction in building carbon emissions, the following table lists several building uses with corresponding predictive Carbon Emission Intensity (pCEI) targets.

LEED Credits

The US Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) Rating Systems are a globally recognized suite of sustainable and green building practice standards. With third-party verification and

TABLE 1

Carbon Emission Intensity for Each Building Typology

Building Typology	CEI Targets (kg $C0_2e$/sf)
Office	1.6
College/University Office	1.6
K-12 School	1.3
Hotel	1.9
Residence Hall	1.6
Low Density Multifamily	1.1
High Density Multifamily	1.6
Dry Lab	4.3
Wet Lab	6.4
Hospital	7.4

Notes:
1. To better reflect building performance over time and account for increasing levels of renewable energy in Electric Grid service, project analysis should use a Building 2035 pCEI target based on forecasted 2035 Electric Grid emission factors.
2. On-site renewable energy benefits are not included in Building pCEI calculations.

---

certification, LEED provides market value for sustainable building practices. Boston and other cities across the nation utilize the LEED Rating Systems to ensure building projects minimize adverse environmental impacts including reducing carbon emissions.

The current requirement of LEED Certifiable should be increased to LEED Gold to ensure sustainability practices remain comprehensive.

Additionally, specific LEED credits that focus on reducing carbon emissions should be required including:

- Integrative Design Process;
- Enhanced and Monitoring;
- Base Commissioning;
- Envelope Commissioning;
- Building Life Cycle Impact Reduction;
- Enhanced Refrigerant Management;
- On-Site Renewable Energy Production; and
- Renewable Energy Procurement

Data Collection and Best Practices

The BPDA should expand project performance data collection, tracking, and reporting. Data should be analyzed and posted on a regular basis, and specific performance standards and targets should be updated as warranted.

A library of exemplary building projects and best practice strategies should be made available for the public and industry professionals seeking information on high-performance buildings and recognizing practice leaders in Boston.

On-site Renewable Energy

Key Recommendations

- Design and develop new buildings to maximize on-site solar energy production, with the goal of completing the building and the energy system together;
- Establish minimum installation standards that include safety, design, and physical constraints;
- Support and allow project participation in the Massachusetts SMART program; and
- Recognize the potential for fluctuation in equipment supply, public incentives, utility, and regulatory conditions.

Solar photo-voltaic (PV) energy is a proven cost-effective strategy for reducing carbon emissions and addressing Boston's need to increase local renewable energy generation. Furthermore, the local solar PV industry employs workers with a range of skillsets and, with the recent expansion of state and federal solar PV incentives, is poised to add even more jobs and businesses. This also provides more opportunities for expanding investments in community-based solar.

The City and BPDA should establish standards for installation of on-site renewable energy systems that fully realize the potential for local renewable energy generation. New standards should focus on solar PV, support design and technical innovation, and accommodate future renewable energy solutions. The goal is to ensure accountability and transparency at every step of the process.

Solar Optimized

Project and building planning and designs should include solar PV solutions from the very first planning steps all the way through system installation and operations. While the goal will be to maximize solar energy production, the City should establish minimum installation standards that consider access, safety, design, regulatory, and inter-connection requirements.

Buildings and structures should be designed with solar energy systems that cover at least:

- 50% of roof areas that are either flat or sloped and oriented between 110 and 270 degrees of true north;
- 90% of uncovered parking decks; and
- 50% of surface parking areas.

Solar energy systems should include emergency access areas, setbacks, and pathways as required by fire and building code standards, and designers must ensure that snow and ice will not shed onto unprotected pedestrian travel areas. Standards should include

Building Spotlight

380 Stuart Street

ZNC Office Building

- LEED Gold
- pCEI of 1.42 kg CO_2e/sf-year
- 11 kW of Solar PV
- 100% renewable electricity
- All electric HVAC systems

physical exceptions for areas that are shaded for 50% or more of daylight hours, and buildings subject to Historic Preservation or other Design Overlay District requirements. Additionally, the total solar energy system output need not exceed 120% of the building's annual energy load.

Solar PV systems should be installed in conjunction with construction completion. If equipment supply, public incentives, regulatory or inter-connection conditions warrant, these regulations should provide means for granting time specific extensions for system installation.

Innovation

The City and BPDA should advance standards that encourage new innovations in on-site renewable energy generation including building-integrated PV, solar thermal, and micro-wind solutions and new ownership and investment models including community solar. Recognizing the critical importance of the Massachusetts SMART program as well as the program's allocation of environmental benefits to utility sponsors, new standards should encourage and allow participation in the SMART program.

Design Review

The City's and BPDA's urban design and Article 37 review processes should be modified to integrate solar optimization in the earliest phases of design including:

- Preliminary building plans delineating solar zone(s) and any exceptions, exclusions, and restrictions;
- System description including layouts, sizes, types, electrical output, controls, storage, and ownership model; and
- Post-installation commissioning reports and operation certificates.

Key Definitions

(A full list of terms used in this document is included in the glossary)

Solar Massachusetts Renewable Target (SMART)

The Solar Massachusetts Renewable Target (SMART) is a financial incentive program to encourage solar energy development in Massachusetts. It provides a rebate in electricity for anyone installing new systems in the state.

Renewable Energy Procurement

Key Recommendations

- New buildings should procure renewable energy as necessary to annually achieve zero net carbon performance;
- Procurement and reporting standards should align with the City's Building Emissions Reduction and Disclosure Ordinance (BERDO) including annual reporting via the BERDO portal;
- Carbon emissions from electric energy use should be accounted for by procuring 100% renewable electricity or an acceptable equivalent; and
- Carbon emissions from non-electric energy use should be accounted for by BERDO Alternative Compliance Payments.

The City should require new building projects that are unable to achieve net zero carbon emission on-site to procure 100% renewable electricity, or the equivalent in environmental benefits. For any carbon emissions from non-electric energy use, BERDO Alternative Compliance Payments will be sufficient to achieve zero net carbon emissions on an annual basis.

When completed, building projects subject to ZNC Building Zoning will also have to comply with the City of Boston's Building Emissions Reduction and Disclosure Ordinance (BERDO) with an emission limit of net zero. BERDO provides a comprehensive framework for reducing and reporting carbon emissions. Each building project should report ZNC Building Zoning and annual BERDO compliance together to streamline the process.

The City should require building projects to procure renewable energy each year for the building's net electricity consumption (annual on-site renewable electricity production subtracted from annual building electricity use) using one or more of the following mechanisms:

- Direct ownership of an off-site project: the customer installs a renewable energy system in another location;
- Power Purchase Agreements: multiple customers can band together and negotiate better terms on their purchases;
- Bundled or Unbundled Renewable Energy Certificates (RECs): the customer purchases a fixed amount of the benefits associated with renewable energy to represent its usage of renewable energy sources; the REC is considered "retired" once the benefits have been used up;

Building Spotlight

Bunker Hill Housing Building F

ZNC Institution

- LEED Gold
- 51% Energy Savings
- 81.9 kW of Solar PV

- Green retail tariffs: the customer purchases electricity at market rate, which has been adjusted to make renewable energy rates lower than conventional fossil fuel rates;

- Utility renewable energy contract/direct access to wholesale markets: the customer signs a multi-year contract agreeing to purchase a fixed amount of energy; and

- Renewable energy investment funds.

All off-site renewable energy procurement must satisfy three minimum requirements: (1) the generator must qualify as a Massachusetts Class I generator as defined by the Massachusetts Department of Energy Resources (DOER), (2) RECs must be retired on behalf of the ZNC building, and (3) the annual purchase commitment must be validated according to BERDO.

Annual Reporting

Building projects should follow the BERDO reporting timeframes and standards for demonstrating ZNC Building Zoning compliance each year. The annual carbon emissions limit is net zero; if the reported carbon emissions exceed this limit, the building project may be subject to a fine for each excess ton of CO_2e.

Carbon Emissions from Electrical Energy Use

The City should establish renewable electricity procurement standards that fully align with the BERDO Compliance Mechanism, including:

- Municipal Aggregation: utilize the City of Boston's Community Choice Electricity program and purchase the 100% renewable electricity option.

- Renewable Energy Certificates: purchase bundled or unbundled RECs that are generated by renewable sources, meet the RPS Class I eligibility criteria, are generated in the compliance period, and retired within six months after use.

- Power Purchase Agreements: enter into a Power Purchase Agreement for energy generated by renewable sources that are generated in the compliance period with the REC that are retired within six months after use.

- Alternative Compliance Payments: make BERDO Alternative Compliance Payments based on electricity carbon emissions. The initial cost of BERDO Alternative Compliance Payment is $234 per metric ton of CO_2e.

Carbon Emissions from Non-Electrical Energy Use

Projects should make BERDO Alternative Compliance Payments for carbon emissions from non-electrical sources including any on-site fossil fuel use. The initial cost of BERDO Alternative Compliance Payment is $234 per metric ton of CO_2e.

Key Definitions

(A full list of terms used in this document is included in the glossary)

Unbundled Renewable Energy Certificates (RECs)

The customer purchases a fixed amount of the benefits associated with renewable energy to represent its usage of renewable energy sources.

Public and Stakeholder Engagement


option
command
command

Public and Stakeholder Engagement

Public Process Timeline

In support of Boston's carbon neutral goals and the 2019 Climate Action Plan, the City reached out to local stakeholders and practice leaders to identify critical partners, key steps, and a timeline for updating Zoning Article 37 and adding a zero net carbon building standard. The BPDA has organized a dual public engagement and technical advisory process model that addresses both the broad significance of the initiative and the technical building complexities.

Extensive public notice, outreach, and stakeholder engagement, including provisions for language translations services, preceded each of the public meetings and resulted in some of the City's largest public planning meetings. All presentations, question and answer responses, and supporting materials have been posted on the Zero Net Carbon Building Zoning Initiative web site.

Public requests for Technical Advisory Group (TAG) members attracted local representatives and regional and national subject matter experts. Members researched strategies and practices, assessed impacts and solutions, and presented materials. Together, the TAGs provided vital process guidance, expert and stakeholder feedback, and key recommendations that formed the cores of the reports. Draft Technical Advisory Group Reports and recommendations were presented and posted for public comment in October of 2021. Ongoing stakeholder meetings provide opportunities for focused discussions and additional feedback.

A Public Meeting will be held to introduce and begin the regulatory adoption process and the draft zoning amendments and proposed policy documents will be posted for public comment. Once the comment period has closed and edits have been made, the proposed zoning amendments and policies will be presented at a public meeting of the BPDA Board of Directors for consideration and approval. With the Board's authorization, the zoning amendments will be presented at a public hearing of the Boston Zoning Commission for consideration and adoption.

TABLE 3

Public Meetings

Subject	Schedule	Attendees
ZNC Public Meeting #1	09-30-2020	233 Attendees
ZNC Public Meeting - Embodied Carbon	04-27-2021	334 Attendees
ZNC Public Meeting #2	09-20-2021	154 Attendees
ZNC Public Meeting #3	09-28-2022	TBD
Boston Planning & Development Agency Public Board Meeting	TBD	TBD
Boston Zoning Commission – Public Hearing	TBD	TBD

TABLE 4

Technical Advisory Group (TAG) Meetings

Subject	Schedule
Low Carbon Bldg TAG #1	11-18-2020
Low Carbon Bldg TAG #2	12-16-2020
RE Procurement TAG #1	01-13-2021
Low Carbon Bldg TAG #3	02-03-2021
Re Procurement TAG #2	02-10-2021
RE Procurement TAG #3	03-10-2021
On-site RE TAG #1	03-30-2021
Low Carbon Bldg TAG #4	04-12-2021
Embodied Carbon TAG #1	05-12-2021
RE Procurement TAG #4	05-19-2021
Embodied Carbon TAG #2	06-02-2021
Onsite RE TAG #3	06-25-2021
Embodied Carbon TAG #3	07-14-2021
Embodied Carbon Tag #4	08-04-2021

TABLE 5

Stakeholder Engagement Meetings

Stakeholder	Schedule
Elkus Manfredi Architects	11-05-2020
Boston City Council - Committee on the Environment	11-19-2020
Built Environment Plus (BE+)	12-15-2020
BPDA Urban Design	01-05-2021
A Better City	01-21-2021
Boston Society of Architecture (BSA)	01-27-2021
Boston Clean Energy Coalition	02-02-2021
Neighborhood Association of Back Bay	02-24-2021
NAIOP / Boston	03-11-2021
CBT Architects	04-06-2021
NBBJ Boston	04-20-2021
NBBJ National	05-26-2021
Boston Clean Energy Coalition	07-20-2021
BPDA Project Review	10-13-2021
Urban Sustainability Director Network	10-13-2021
A Better City	10-18-2021
Mass Timber Accelerator	10-19-2021
Medical Academic and Scientific Community Organization (MASCO)	11-15-2021
A Better City	12-14-2021
Turner Construction	12-17-2021
Payette Architects	01-05-2022
Urban Land Institute / Boston (ULI)	02-08-2022
Massachusetts Building Congress	02-16-2022
Northeast Energy Efficiency Partnership (NEEP)	02-22-2022

Acknowledgements

Technical Advisory Group: Embodied Carbon

Anthony Pak – Priopta

Alison Nash – DiMella Shaffer

Andrea Love – Payette

Brad Mahoney – Millennium Partners Boston

Caroline Shannon – Howeler + Yoon Architecture

Chen Qin – Harley Ellis Devereaux

Christopher Stanley – Trinity Financial

Ciarán Smyth – BALA Engineers

Courtney Koslow – Beacon Communities

Dan Whittet – AHA Consulting Engineers

J. Daniel Bailey – Takeda Pharmaceuticals

Dennis Carlberg – Boston University

Ivan Lee – Morrison Hershfield

James Rogers – Turner Construction

Jennifer Effron – Boston Society of Architects

Jim Newman – Linnean Solutions

Julie Janiski – Buro Happold

Kayla Natividad – NSG Pilkington North America

Kevin Maguire – Oxbow Urban

Lori Ferriss – Goody Clancy

Martine Dion - SMMA

Meghan Lewis – Carbon Leadership Forum, University of Washington

Meredith Elbaum – Built Environment Plus

Michael Gryniuk – LeMessurier

Michael Orbank – Commodore Builders

Michelle Apigian – ICON Architecture

Michelle Lambert – Lambert Sustainability

Nicole St. Clair Knobloch – Olifant, LLC

Olivia Humphrey – Jacobs

Patrick Kenny – Thornton Tomasetti

Paul Richardson – Buro Happold

Rachelle Ain – Utile Design

Steven Burke – Consigli Construction Company, Inc.

Tamar Warburg – Sasaki Associates, Inc.

Tom Chase – New Ecology, Inc.

Turan Karakus – BR+A Consulting Engineers

Technical Advisory Group: Low-Carbon Building

Abe Menzin – Samuels

Adam Jennings – AHA Consulting Engineers

Amy Barad – Massachusetts Clean Energy Center

Andrea Love – Payette

Andrew Hall – John Moriarty and Associates

Anwen Robinson – Boston Development Group

Blake Jackson - Stantec

Brad Mahoney – Millennium Partners Boston

Chris Gray, PhD PE – RENU Communities

Christopher Schaffner – The Green Engineer

Claire McKenna – Rocky Mountain Institute

Darren Port – Northeast Energy Efficiency Partnership

Gilbert Delgado, FAIA – Northeastern University

Jacob Higginbottom – EYP

Jeffrey Rios – AKF Group

Joelle Jahn – WSP USA

Julie Janiski – Buro Happold

Julie Klump – Preservation of Affordable Housing

Kate Bubriski – Arrowstreet

Katie Raymond – Epsilon Associates

Ken Lambert – International Masonry Institute

Kendra Halliwell – ICON Architecture

Kristen Fritsch – Elkus Manfredi Architects

Lauren Baumann – New Ecology

Martine Dion - SMMA

Matthew Fickett – EYP

Michelle Apigian – ICON Architecture

Norm Lamonde – Turner Construction Company

Rebecca Hatchadorian – Arup

Samira Ahmadi – enviENERGY Studio

Shirine Boulos Anderson – Ellenzweig

Travis Anderson – Placetailor

Winston Vaughan – Health Care Without Harm

Yve Torrie – A Better City

Technical Advisory Group: Onsite Solar & Renewable Energy Procurement

Angela O'Connor – Vicinity Energy

Ben Myers – Boston Properties

Cameron Peterson – Metropolitan Area Planning Council

Chris Gray – RENU Communities

Cynthia Cresswell Cook – Earth Energy

David Eisenbud – Distributed Solar Development

Dennis Carlberg – Boston University

Emily Jones – Local Initiatives Support Corporation

Isaac Baker – Resonant Energy

James Liebman – HMFH Architects

James Manzer – ReVision Energy

Joelle Jahn – WSP Engineering

Julie Curti - Metropolitan Area Planning Council

Patrick Haswell – Vicinity Energy

Scott Johnstone – Vanasse Hangen Brustlin

Scott McBurney – Vicinity Energy

Seth Federspiel – City of Cambridge

Winston Vaughan – Health Care Without Harm

Yve Torrie – A Better City

Consultants

Alejandra Menchaca – Thornton Tomasetti

Gunnar Hubbard – Thornton Tomasetti

Colin Schless – Thornton Tomasetti

Nicole Peterson – Thornton Tomasetti

Jacob Knowles – BR+A Consulting Engineers

Debra Perry – Cadmus Group

Zack Wyman – Cadmus Group

Chad Laurent – Cadmus Group

Steve Tobey – Cadmus Group

Erin McDade – Architecture 2030

Vincent Martinez – Architecture 2030

Charles Eley – Architecture 2030

Jay Wickersham – Noble, Wickersham & Heart LLP

Barbara Landau – Noble, Wickersham & Heart LLP

Bennet Heart – Noble, Wickersham & Heart LLP

City of Boston Staff

Arthur Jemison, Chief of Planning & Director of BPDA

Rev. Mariama White-Hammond, Chief of Environment, Energy, and Open Space

Alison Brizius, Commissioner of the Environment

Aidan Callan - Environment, Energy and Open Space

Amber Galko – Boston Planning & Development Agency

Bryan Glascock – Boston Planning & Development Agency

Hannah Payne – Environment, Energy and Open Space

Jeff Hampton – Boston Planning & Development Agency

John Dalzell – Boston Planning & Development Agency

Katherine Eschel – Environment, Energy and Open Space

Katherine Latoff – Boston Planning & Development Agency

Kathleen Pedersen – Boston Planning & Development Agency

Maya Kattler-Gold – Boston Planning & Development Agency

Maura Zlody - Environment, Energy and Open Space

Peter Sun – Boston Planning & Development Agency

Richard McGuinness, Deputy Director for Climate Change and Environmental Planning – Boston Planning & Development Agency

Chris Busch – Boston Planning & Development Agency

Joe Christo – Boston Planning & Development Agency

Joseph LaRusso – Environment, Energy, and Open Space

Lauren Shurtleff, Director of Planning – Boston Planning & Development Agency

Michael Cannizzo, Director of Urban Design – Boston Planning & Development Agency

Olivia Rouse – Boston Planning & Development Agency

Susan Cascino – Environment, Energy and Open Space

Travis Anderson – Boston Planning & Development Agency

Will Visco – Boston Planning & Development Agency

Glossary of Key Terms

Article 37: Green Buildings and Climate Resiliency Review Procedures
This section of the Boston Zoning Code states that all projects subject to Article 80 Large Project Review are planned, designed, constructed, and managed to minimize adverse environmental impacts; conserve natural resources; are resilient to climate change; promote a more sustainable city; and enhance the quality of life in Boston.

Embodied Carbon
Embodied carbon is the amount of carbon dioxide that was emitted during the construction of the building. This includes manufacturing, transportation, installation, maintenance, and disposal of materials.

Environmental Product Declaration (EPD)
An Environmental Product Declaration (EPD) is a report from a product's manufacturer. It is a life cycle assessment (LCA) on the product and analyzes how much carbon dioxide was released at every step of the product's creation.

Life Cycle Assessment (LCA)
This is an analysis of the total amount of carbon dioxide emitted throughout the course of a product's life. It includes raw materials and extraction, manufacture, transportation, usage, and destruction.

Solar Massachusetts Renewable Target (SMART)
The Solar Massachusetts Renewable Target (SMART) is a financial incentive program to encourage solar energy development in Massachusetts. It provides a rebate in electricity for anyone installing new systems in the state.

Unbundled Renewable Energy Certificates (RECs)
The customer purchases a fixed amount of the benefits associated with renewable energy to represent its usage of renewable energy sources.

Appendix: Technical Advisory Group Reports

Image Source: Haycon Inc.

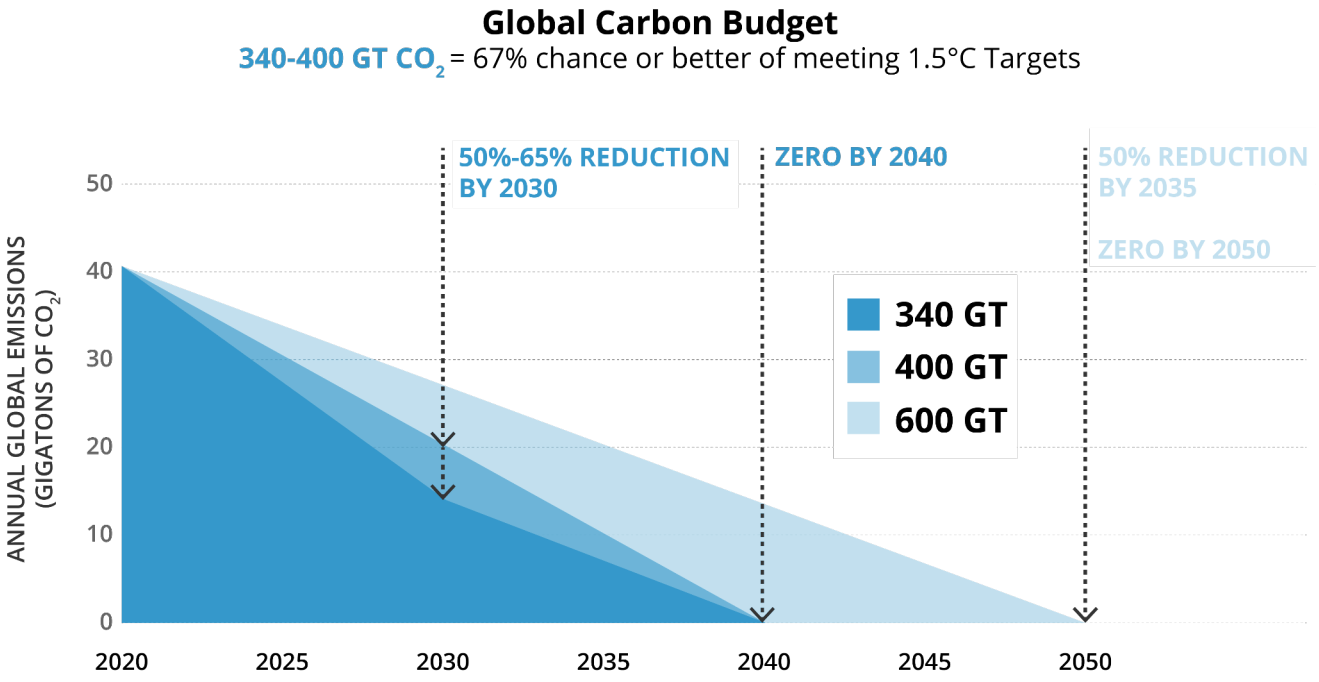
Appendix I:

Boston Zero Net Carbon: Embodied Carbon Reduction Technical Advisory Group Report

Introduction

The Urgency Behind Reducing Embodied Carbon

The 2015 Paris Agreement established the goal of keeping planetary warming to below 2°C while pursuing efforts to limit warming to 1.5°C. The world is quickly depleting its 1.5°C carbon budget. According to the IPCC's sixth assessment report, as of January 1, 2020, the remaining global carbon budget for a good probability (67% chance or better) of avoiding more than 1.5°C warming is 340-400 Gt CO2 (AR6 budget). To meet this budget CO2 emissions must be reduced 50% to 65% by 2030 and to zero CO2 emissions by 2040:

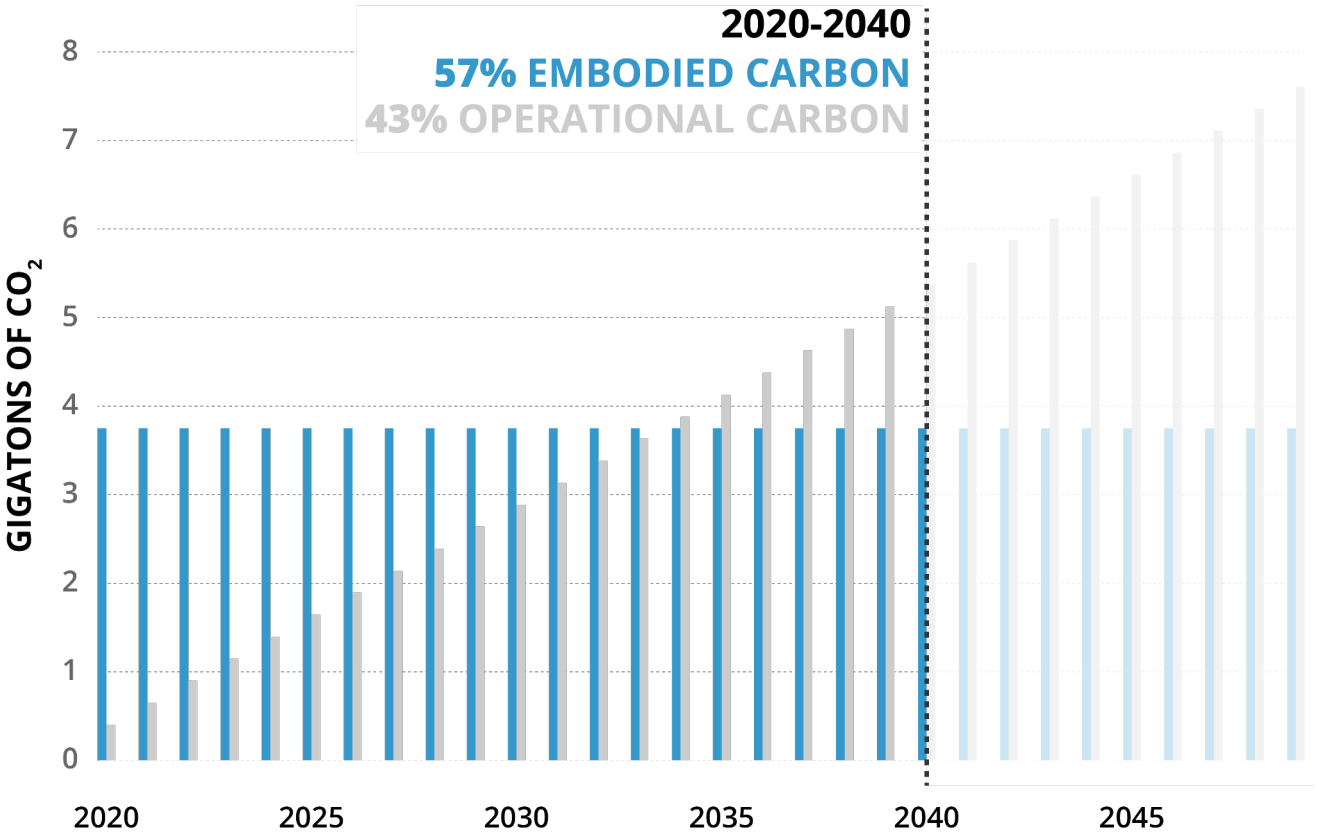


Data Sources: UN IPCC AR6

We are currently in the midst of the largest wave of urban growth in human history. In order to accommodate this growth, we expect to add 2.4 trillion ft2 of new floor area to the global building stock by 2060, effectively doubling the current global building floor area. Most of this growth will occur in cities.

When we look at all the new construction projected to take place between now and the target year of 2040, we see the critical role embodied carbon plays:

Total Carbon Emissions of **Global New Construction**
with no building sector interventions



Data Sources: UN Environment Global Status Report 2017; EIA International Energy Outlook 2017

Without interventions, by 2040 embodied carbon will be responsible for a larger proportion - nearly 60% - of global new construction emissions than operational carbon. And unlike operational carbon emissions, which can be reduced over time with building energy upgrades and the use of renewable energy, embodied carbon emissions are locked in place as soon as a building is built. It is critical that the building design and construction community act now and pursue all opportunities to reduce embodied carbon and that we achieve zero emissions by 2040.

Definitions of Embodied & Operational Carbon

Embodied Carbon refers to the greenhouse gas emissions arising from the manufacturing, transportation, installation, maintenance, and disposal of building materials. Upfront embodied carbon (also known as upfront carbon) refers to the greenhouse gas emissions released before a building or infrastructure starts being used. This is particularly important for reaching GHG targets for 2030 because these emissions will be "frontloaded" in the next ten years, unlike annual operating emissions or end-of-life emissions, which will occur later and/or gradually over time.

Operational Carbon refers to the carbon emitted during the in-use phase of a building and includes the energy sources to power, light, heat and cool the building.

Total Carbon or whole life carbon of a building is the sum of both embodied and operational carbon. To reach net zero total carbon or whole life carbon, a building must minimize both the operational and embodied carbon over the building's life cycle and offset any remaining carbon to reach zero.

Achieve Zero Embodied Emissions

What does 'zero' mean for embodied carbon? There are a few ways to think about net zero for embodied carbon, depending on what life cycle stages are included. A net zero embodied carbon building is one where the sum total of greenhouse gas (GHG) emissions and removals over its life cycle (from cradle to grave[06]) are significantly minimized, meet local carbon emissions targets (e.g. kg CO2e/sf-yr), and with additional 'offsets', equal zero. Due to the urgency of meeting climate change targets, focusing on upfront carbon can be helpful for focusing on the most urgent emissions. A net zero upfront carbon building is one where the sum total of GHG emissions, excluding 'carbon sequestration', from Modules A1-A5 is minimized, meets local carbon targets (e.g.kgCO2e/m2), and with additional 'offsets', equals zero. [07]

Where local carbon targets have not been set, this means that a net zero embodied carbon building has adopted all available strategies to minimize embodied carbon across the life cycle and offset its remaining footprint.

Global organizations have set the following embodied carbon reductions targets to indicate which reductions need to be made on projects to reach net-zero:

- Architecture 2030: 45% by 2025, 65% by 2030, and net-zero by 2040; [08]
- LETI: 40% by 2025, 60% by 2030; [09]
- C40: 30% by 2025, 50% by 2030; [10]
- WGBC: 40% by 2030, net-zero by 2050. [11]

---

06 Modules A1-A5, B1-B5 and C1-C4

07 WLCN, RIBA, LETI (2021). Improving Consistency in Whole Life Carbon Assessment and Reporting: Carbon Definitions for the Built Environment, Buildings and Infrastructure. Accessed at: https://b80d7a04-1c28-45e2-b904-e0715cface93.filesusr.com/ugd/252d09_879cb72ce-bea4587aa860b05e187a32a.pdf

08 Architecture 2030. (n.d.). 2030 Challenge for Embodied Carbon. Retrieved August 2021 from https://architecture2030.org/2030_challenges/embodied/

09 London Energy Transformation Initiative (LETI). (2020). LETI Embodied Carbon Primer. https://www.leti.london/ecp

10 C40 Cities. (n.d.). Clean Construction Declaration. Retrieved August 2021 from https://www.c40.org/clean-construction-declaration

11 World Green Building Council (WGBC). (2019). Bringing Embodied Carbon Upfront. https://worldgbc.org/news-media/bringing-embodied-carbon-upfront

What are the strategies for minimizing embodied carbon? Broadly, there are four categories of strategies for reducing embodied carbon:

» Build less, reuse more through extending the life of existing buildings and reducing minimum floor area;
» Design lighter and smarter buildings that increase structural and material efficiency and reuse existing materials;
» Replace high-carbon materials with low-carbon ones, through evaluating the carbon footprint of different systems and assemblies during design and selecting carbon-storing materials where possible; and
» Optimize materials and procurement by sourcing the product with the lowest carbon product available that meets a project's specifications.

Additionally, there are process strategies that are key to achieving reductions on projects, including:

» Use of life cycle assessment tools to measure building embodied carbon and track reductions;
» Collaboration across project teams between architects, engineers, owners, builders, and suppliers is critical to success.

Recommendations

Overview / introduction

Led by the Embodied Carbon Working Group, the Zero Net Carbon (ZNC) Embodied Carbon Technical Advisory Group (TAG) reviewed and considered a wide range of policies, practices, and research to best understand built environment practices and strategies for reducing the carbon emissions associated with building and infrastructure construction materials. The TAG has organized recommendations under the following framework:

- Policy, Practice, and Awareness - recommendations are NOT limited to zoning and may impact one, two, or, ideally, all three impact areas.
- Immediate, Near-Term, and Long Term - recommendations should be prioritized for carbon reduction impact and feasible implementation.
- Action Oriented - recommendations should be task specific and, wherever possible, identify potential partners, resources and precedents.

Policy	Practice	Awareness
[01] Climate Action Plan: Update with embodied carbon goals and strategies	[06] Pilot Programs / Demonstration Projects	[9] Recognition for Best Practices
1. Building reuse and deconstruction ordinance	7. Incentives	10. City Capacity and Expertise
3. Require LEED embodied carbon-related/LCA Credits	8. BPDA Advisory Group	11. Workforce Development
4. Require whole-building LCA in zoning/ permitting process		12. AEC Industry Resources
5. Municipal & State collaboration		

1. Include Zero Net Embodied Carbon in the Climate Action Plan Update

Include goals and strategies for reducing embodied carbon in the built environment and establishing a Zero Net Embodied Carbon Standard for all new construction.

For Boston to meet our carbon neutral goals reducing construction embodied carbon emissions, currently 23% of our annual global GHG emissions, is critical. Boston's Climate Action Plan (CAP), which has been updated on a regular basis, provides the City with a framework defining and prioritizing City. Developed in partnership with Boston's residents and stakeholders, the CAP communicates the City's policy goals and expectations. Action item #3 of the Climate Action Plan 2019 Update set in motion this Zero Net Carbon Building Zoning Initiative.

Goals	Implement a comprehensive embodied carbon reduction strategy that takes advantage of complementary policy pathways and includes strategies specific to building materials, products, building waste and material recovery, local production, transportation, and consumption emissions (e.g. Building disclosure, targets & thresholds, data collection & re-evaluation)
Action	Include embodied carbon reduction goals and strategies, including implementation of a zero net embodied carbon standard, in the next climate action plan update.
Timing/ Sequencing	pending determination of the City's next Climate Action Plan Update schedule.City of Boston Climate Action Plan 2019 Update

Precedents (CAPs with embodied carbon):

- Albany 2019 Climate Action and Adaptation Plan
- City of Austin Climate Equity Action Plan
- Eugene Community Climate Action Plan
- King County 2020 Strategic Climate Action Plan
- L.A. Green New Deal Sustainable City pLAn
- Oakland 2030 Equitable Climate Action Plan
- Phoenix Climate Action Plan
- San Francisco Climate Action Plan
- Vancouver Climate Emergency Action Plan

2a. Promote Building Reuse

Reusing existing buildings rather than replacing them is one of the most effective methods of reducing embodied carbon because it avoids emissions resulting from the production and construction of new building elements.[12] In particular, projects that are able to retain and reuse primary structural and enclosure components will yield the greatest embodied carbon savings because these two systems are typically the most carbon-intensive components within buildings. Reuse also minimizes the environmental and human health impacts of demolition and construction waste.

Building reuse also offers environmental and social co-benefits. For example, traditional building materials, like wood windows or masonry facades, are frequently able to be repaired over time rather than requiring periodic replacement, which further reduces embodied carbon over the building's life. See 2b for additional information.

Goal	Avoid embodied emissions of new materials by reusing existing buildings in part or in whole.
Goal	Reduce emissions and the local environmental and health impacts of construction waste.
Action	Include embodied carbon reduction goals and strategies, including implementation of a zero net embodied carbon standard, in the next climate action plan update.
Action *(Immediate)*	Identify barriers to existing building reuse and support implementation of Zero Waste policy and ordinances.
Action *(Immediate)*	Evaluate opportunities to coordinate with and support Article 85 or other city preservation requirements.
Action *(Immediate/Mid-Term)*	Support workforce development to create a skilled labor force that is trained to retrofit existing and historic buildings to bring them into compliance with performance standards without damaging existing fabric or introducing risks for future damage.
Action *(Mid-term)*	Include the upfront impacts of demolition in embodied carbon targets for proposed new construction. If an existing building or portion thereof is retained, treat the avoided carbon as a carbon credit or offset.

Precedents:

» Los Angeles Adaptive Reuse Ordinance
» San Francisco Climate Action Plan (and other action plans - add some here?)

12 *"Bringing Embodied Carbon Upfront," World Green Building Council*

2b. Promote Building Deconstruction and Material Salvaging

In cases where the entire building cannot be saved and reused, deconstruction and the reuse of building elements or materials is another path to reducing overall embodied carbon of the new project. The circular economy of manufacturing, using and then reusing (rather than demolishing and landfilling) building materials is emerging as an important aspect of reducing both carbon and waste in the City of Boston.

Goal	Avoid the embodied emissions of new materials by reusing existing building components and materials.
Goal	Reduce the emissions and the local environmental and health impacts of construction waste.
Goal	Foster circular economy in the local deconstruction market by utilizing reusable and recycled materials in new construction.
Action *(Immediate)*	Participate in City of Boston's Deconstruction Pilot (in development), a Zero Waste Boston initiative.
Action *(Immediate/Mid-Term)*	Support workforce development to create a skilled labor force that can salvage and reinstall existing building components.
Action *(Immediate/Mid-Term)*	Support city and private sector actions to foster an economy and market place for salvage and reuse.

» City of Boston Deconstruction Pilot (in development)
» Portland Deconstruction of Buildings Law
» San Antonio Deconstruction and Salvage Initiative
» Pittsburgh Building Deconstruction Policy (in development)
» Mass DEP: RecyclingWorks Blog - Building up Deconstruction
» Mass DEP: Construction Waste Management Plan Template
» City of Houston Building Materials Reuse Warehouse

3. Require achievement of embodied carbon related LEED Credits

The LEED Green Building Rating System has been an integral component of permitting in Boston since the adoption of Article 37 in 2007, requiring LEED 'Certifiability' for all projects undergoing Article 80B Large Project Review. Existing familiarity with the rating system provides an easy pathway into requiring specific LEED credits that address embodied carbon as part of a holistic approach to ensuring sustainable and resilient development projects.

Goal	Expand awareness and practice of embodied carbon reduction by utilizing known and already adopted rating systems. Utilize existing LEED credits based on practices and methodologies that have already been written and reviewed by the green building community.
Action *(Immediate)*	Update Article 37 to require achievement of specific LEED Credits and associated points related to embodied carbon. Potential credits to be adopted are listed below.

3a. LEED Credit - Building Life-Cycle Impact Reduction, version 4.1

» Option 1. Building and Material Reuse - if applicable to the project
- Path 1: Maintain Existing Structural Elements: Walls, Floors, Roofs, and Envelope- (15%, 30%, 45%, 60%, 75%)
- Path 2: Maintain Interior Non structural Elements (30%)

» Option 2. Whole-Building Life Cycle Assessment - for all projects
- Path 1- Conduct a life cycle assessment of the project's structure and enclosure (S+E) only
- Path 2- LCA of S+E must demonstrate a 5% reduction compared with a baseline in 3 of 6 listed impact categories, one of which must be global warming potential (i.e. embodied carbon)
  - global warming potential (greenhouse gases), in kg CO2e;
  - depletion of the stratospheric ozone layer, in kg CFC-11e;
  - acidification of land and water sources, in moles H+ or kg SO2e;
  - eutrophication, in kg nitrogen eq or kg phosphate eq;
  - formation of tropospheric ozone, in kg NOx, kg O3 eq, or kg ethene; and
  - depletion of nonrenewable energy resources, in MJ using CML / depletion of fossil fuels in TRACI
- Path 3- LCA of S+E must demonstrate a 10% reduction compared with a baseline in 3 of 6 listed impact categories, one of which must be global warming potential (i.e. embodied carbon)
- Path 4- Meet requirements of Path 3 and incorporate reuse and/or salvage materials into the project's structure and enclosure for the proposed design. Demonstrate reductions compared with a baseline building of at least 20% reduction for global warming potential and demonstrate at least 10% reduction in two additional impact categories listed below

3b. LEED Credit - Building Product Disclosure and Optimization- EPD's, v4.1

» Option 1- Environmental Product Declaration
- Use at least 20 different permanently installed products sourced from at least 5 different manufac-

turers that meet one of the disclosure criteria (Disclosure only)

» Option 2. Embodied Carbon/LCA Optimization
  - Use products that have a compliant embodied carbon optimization report or action plan separate from the LCA or EPD. Use at least 5 permanently installed products sourced from at least 3 different manufacturers (Disclosure + Action Plan)

3c. LEED Credit - Building Product Disclosure and Optimization- Sourcing of Raw Materials, v4.1

» Use products sourced from at least three different manufacturers that meet at least one of the responsible sourcing and extraction criteria below for at least 15%, by cost, of the total value of permanently installed building products in the project.
  - Bio-based materials
  - FSC Wood products
  - Materials Reuse

3d. Pilot LEED Credit- Procurement of Low Carbon Construction Materials

» Step 1 - Building Embodied Carbon Intensity - Baseline Calculation:
  - Use materials embodied carbon intensity baselines (mECIb) published by the University of Washington/Carbon Leadership Forum or other approved data provider to calculate the embodied carbon for materials used in the project.
  - The following materials must be included if they are used on the project:
    - Concrete
    - Steel
    - Timber
    - Metal Framing
    - Glazing
  - Multiply the appropriate mECIb by the total quantity of each material used in the construction of the project.

» Step 2 - Building Embodied Carbon Intensity – Verified Reduction Calculation:
  - Utilizing a third party verified Environmental Product Declaration with applied UWCLF methodology, determine the actual material embodied carbon intensity (mECIa) for the materials used in the project.
    - Points are awarded base on the reduction in bECIb and bECIa. as follows:
    - Low range reduction (0-30%) - 1 Point
    - Mid-range reduction (30+%) - 2 Points

4. Integrate Whole Building Life Cycle Assessment into Permitting Review

Measuring embodied carbon is key to tracking progress towards net zero and to evaluating the highest impact, most cost-effective solutions to reducing embodied carbon on a project. Embodied carbon is measured as global warming potential (GWP) using a methodology called life cycle assessment (LCA). A whole building LCA measures the environmental impacts of a building over its full life cycle, from raw material extraction through end-of-life and disposal.

Similar to the way that energy use is calculated on a per square foot basis to express the energy use intensity (EUI) of a building,[13] the embodied carbon intensity of a building can be calculated using a whole building LCA to quantify the embodied carbon per floor area (kgCO2e/sf).

LEED v4 (see recommendation 3), the Living Building Challenge, and the Zero Carbon Certification are examples of green building certifications that already require or reward points for performing a whole building LCA and measuring the embodied carbon intensity of a building. Many cities and countries outside of the United States are already moving towards requiring the disclosure of embodied carbon intensity of a building alongside its operational carbon or energy use intensity (see precedents below).

Goal *(Short-Term)*	Build capacity of local practitioners to complete whole building life cycle assessments (LCA) and identify embodied carbon "hot spots" in their buildings.
Goal *(Long-Term)*	Establish embodied carbon intensity benchmarks for different building types and set meaningful targets for reaching net zero embodied carbon over time.
Action *(Immediate)*	Request a whole building LCA report (that aligns with the LEED v4.1 Building life cycle impact reduction credit reporting requirements or similar) as part of project filings.
Action *(Long-Term)*	Require certain project types to meet local / regional building carbon intensity targets (e.g. kgCO2e/sf for different building types).

Precedents:

- Netherlands Building Decree 2012
- City of Vancouver (B.C.) Green Building Rezoning Requirements
- New London Plan
- Copenhagen Bæredygtighedsklassen ("The Sustainability Class")
- Assessment System for Sustainable Building (BNB) National LCA requirement for German federal buildings

13 *https://www.energystar.gov/buildings/benchmark/understand_metrics/what_eui*

5. Municipal / State Policy Alignment and Collaboration

Municipal policies and programs focused on reducing embodied carbon are new, and the City of Boston can learn alot from the successes and failures of approaches being tried in the region to help refine and develop the City of Boston's approach. By working together, education and other resources needed to assist the industry in reducing embodied carbon and meeting the City of Boston's goals can be shared, reducing the burden on the City of Boston. Additionally, alignment of approaches within the region will make it easier for building owners and professionals to understand, follow and comply with the City of Boston's programs and policies.

Goal	Ensure consistency and alignment of regulatory policies across jurisdiction
Goal	Unlock Boston Regional opportunities including: Shared material reuse markets. » Shared education and training programs. » Uniform policy approaches, reporting requirements, and practice requirements (as needed).
Action *(Near-term)*	Establish partnerships with local organizations and municipalities and support regular convening of public officials and stakeholders

Precedents:

» Zero Carbon Buildings - Municipal Summit Built Environment Plus
» Electric Futures - Practical Approach to Regulation and Implementation - BSA
» Regional municipality collaboration: Bay Area Low Carbon Concrete Code Working Group (funded by the Bay Area Air Quality Management District)
» Metro Mayors Coalition (Boston)
» Mass DEP Construction and Demo Working Group
» Carbon Leadership Forum (CLF) Boston Reuse & Policy Groups

6. Pilot Programs / Demonstration Projects

Boston has a long history of effectively utilizing pilot programs, demonstration projects and similar partnership approaches to better understand and accelerate the adoption of new practices.

Goal	Rapidly advance specific low carbon building practices and policies and expand local expertise, businesses, and material / product supply.
Action *(Immediate / Near-term)*	Identify strategic interventions and potential partners and resources to launch programs and initiatives.

Potential Focuses:

» Mass Timber Practices and Tall Wood Buildings
» Low Carbon Concrete
» Carbon-Storing Materials
» Deconstruction
» Material Salvage & Reuse

Precedents:

Boston Mass Timber Acceleration Program

7. Consider Incentives for Best / New Practices

Establishing incentives encourages innovation and early adoption of best practices. The City of Boston, in collaboration with neighboring municipalities and the State of Massachusetts, should consider a wide range of potential incentives that would support early adoption of the policies proposed in recommendations 1-5.

Examples of relevant incentives include:

» Density Bonus
» Expedited Permitting

» Reduced Permitting Fees
» Tax Credits for manufacturers who create EPD's
» Tax credits for projects that surpass minimum target reduction

Goal *(Immediate)*	Increase speed of adoption of embodied carbon recommendations and policies and expand local expertise and practices.
Action *(Immediate)*	Work with local and regional partners to identify potential resources and means to incentivise practices
Action *(Immediate / Near-term)*	Update City policies to incorporate potential structural (e.g. building height and density bonuses), regulatory, and financial incentives.

Precedents:

» Somerville Zoning Ordinance
» Newton Lower embodied carbon options for multifamily buildings
» City of Seattle Priority Green Expedited and Green Building incentive programs
» Vancouver Green Building Rezoning Requirements
» French Énergie Positive et Réduction Carbone (E+C-) pilot program

8. Establish Professional Expert Advisory Group

The architectural, engineering, construction and sustainability professional community have a long history of partnering with the City and assisting in policy development. The formulation and evolution of embodied carbon policies would benefit from the expert guidance and support of an advisory group. The responsibility of the advisory group should include the following:

» Provide strategic direction on proposed policies
» Focus on the development and evolution of EC policies
» Track policy outcomes
» Readjust baselines and revise target reduction goals through cyclical reviews
» Curate a database of innovative projects and case studies
» Advise on pilot programs (recommendation 6) and Incentives (recommendation 7), Review outcomes, and develop policy strategies responding to regional market context

Goal *(Immediate / Ongoing)*	Support ongoing City and BPDA embodied carbon policy and program development and assist with the implementation of new strategies and policies and including integration of Boston's diversity equity and inclusion goals on the professional expert advisory group and with stakeholder engagement and policy actions.
Action *(Immediate / Near-term)*	Work with local partners to establish a professional expert advisory body with defined purpose, engagement and work plan, and schedule.

Precedents:

» Article 80B Project Impact Advisory Groups
» Boston Civic Design Commission
» Green Ribbon Commission

9. Recognize Best / New Practices and Projects

Celebrating advances and innovations in low embodied carbon building design and construction can accelerate the adoption of new practices, technologies, and products. Best practice case studies, awards and related recognition events both recognize the efforts of practice leaders and illuminate new practices.

Goal	Raise awareness of local case studies and best practices.
Goal	Incentivize continued leadership and innovation.
Action *(Immediate / Near and Long-term)*	Identify partners including the BE+, BSA, and CLF, and resources to identify recognition programs and case studies.

Precedents:

» BE+ Green Building Showcase
» NYSERDA Buildings of Excellence Competition
» AIA COTE Top 10 Awards

10. City Capacity and Expertise - Training, Staffing, Management

The field of embodied carbon in building materials, in both research and practice, is evolving rapidly in alignment with the growing understanding of urgency around meeting our climate goals. Continuing education for city staff on LCA tools and practices, innovative lower carbon materials and products being developed, and other policy precedents being adopted nationally will be necessary to stay current and informed.

Goal	Increase city staff capacity to efficiently and professionally advance critical practices and manage review project processes pertaining to embodied carbon analysis.
Action *(Immediate)*	Emphasize the importance of City staff and capacity to engage project planning teams and effectively and timely respond to project proposals and regulatory filings.
Action *(Immediate)*	Develop a continuing education program and/or partner with organizations such as CLF, BE+ and others to provide resources and training to city staff.

Precedents:

» Carbon Free Boston Report

11. Workforce Development

Inherent in many of these low embodied carbon recommendations is the expansion of local manufacturing, processing, and resourcing of materials and products. Expansion of our local workforce and skill specialization will be essential to meeting the new business and employment opportunities that will arise with new practices.

Goal	Increase local workforce capacity to respond to new practices, work, and business opportunities to reduce embodied carbon in the built environment. Ensure opportunities are provided equitably and support Boston's diversity, equity and inclusion goals.
Action *(Immediate / Near-term)*	Assess workforce capacity, opportunities, and needs.
Action *(Immediate / Near-term)*	Identify resources and partners to provide and support workforce training programs.

Precedents:

» Massachusetts Clean Energy Center (MassCEC)
» Boston Office of Workforce Development

12. Architecture, Engineering and Construction Industry Professionals

Action to reduce embodied carbon requires collaboration across professions, sectors and regions. Partnering with existing networks focused on the reduction of embodied carbon and related sustainability education actions can build capacity across the industry to collaborate, expand knowledge, advance best practices and include low embodied carbon strategies and materials in building projects.

Goal	Increase resources and educational offerings for architecture, engineering and construction industry professionals to ensure consistency and ease.
Action *(Immediate / Near-term)*	Identify collaboration and education opportunities and needs, potential resources and partner organizations to provide and support collaboration and education offerings.

Precedents:

» Carbon Leadership Forum (CLF) Boston Hub
» Built Environment Plus (BE+)
» Boston Society for Architecture
» Boston Green Ribbon Commission

Image Source: https://www.architects.org/mass-timber-accelerator/mass-timber-accelerator-2022-recipients

Appendix II:

Boston Zero Net Carbon Low Carbon Buildings Technical Advisory Group Report

Prepared for:
The City of Boston / Boston Planning & Development Agency

Prepared by:
Alejandra Menchaca & Colin Schless
Thornton Tomasetti, Inc.
T 617.250.41770
AMenchaca@ThorntonTomasetti.com
CSchless@ThorntonTomasetti.com
www.ThorntonTomasetti.com

Jacob Knowles
BR+A Consulting Engineers
T 617.925.8376
jknowles@brplusa.com
brplusa.com

Table of Contents

1

SECTION 1

Summary & Process

1.1 Introduction

The City of Boston has set the target of meeting carbon neutrality by the year 2050, as well as a framework on how to meet this goal. One of the key milestones that must be met includes ensuring that any new construction has Zero Net Carbon emissions through the design of low carbon buildings that use renewable energy (on-site or off-site) to offset their expected annual carbon emissions. This document is focused on the topic of low carbon buildings for new structures of at least 20,000 square feet. Three other documents, generated by a separate consultant team, will cover the topics on on-site renewables, off-site renewable energy prodrurement, and embodied carbon guidelines. The Zero Net Carbon Building Zoning establishes standards for low carbon buildings, the installation of onsite renewable energy, and the procurement of renewable energy including renewable energy credits sufficient for annually achieving net zero carbon emissions. New development projects and individual buildings approved under the ZNC Building Zoning will be required to annually comply with the City of Boston's Building Energy Reporting & Disclosure Ordinance (BERDO) except with an annual maximum of zero net carbon emissions.

The main objective of this report is to provide the Boston Planning and Development Agency (BPDA) with a list of recommendations to define a zoning framework for buildings to meet the definition of being *low carbon*. A low carbon building is one that generates significantly lower operational carbon emissions than their business-as-usual counterparts due to HVAC systems that maximize energy recovery and ultra high performance envelopes that minimize both heating and cooling loads. Low carbon buildings are good candidates to achieve Zero Net Carbon goals because their first cost premium is frequently below 1% of the total cost (*Built Environment Plus - Massachusetts is Ready for Net Zero 2021 report).*

The compliance framework presented in this report was developed through extensive research, discussions with the BPDA and City of Boston, and meetings with the Low Carbon Buildings Technical Advisory Group. The proposed compliance path is subdivided into four general sections:

- **Performance Requirements.** The framework relies on meeting a minimum two key performance requirements: an absolute Carbon Emissions Intensity (CEI) calculated as annual carbon emissions per unit area (only applicable for the most common building typologies) and meeting a relative Percent Reduction in emissions with respect to the ASHRAE baseline (applicable to all building typologies). In recognition that no two buildings are equal in design or expected operation, this two-pronged approach to demonstrate high performance should enable both the design teams and the City of Boston to have a deeper understanding of a particular building's carbon profile and how it compares to similar buildings of the same typology.

  Moreover, the CEI threshold will be consistent with the future BERDO 2.0 caps on carbon emissions for existing buildings, while the Percent Reduction requirement will be familiar to all those project teams aiming for optimized energy performance within the LEED and MA Stretch Code frameworks. Both values will stem from the same energy model.

- **Exceptional Performance.** Additional recommendations to the City of Boston include making the zoning approval process easier (with less modeling) for those teams comitting to obtaining a high performance certification program such as Passive House (PHIUS or PHI), Living Building, or E+ Green Building Program. Pursuing exemplary levels of third party certification simplifies the process for both the design teams (fewer energy models and compliance paths to track) and the BPDA (third party reviewing).

- **Modeler Accreditation.** Similar to requirements for licensure or accreditation in other fields, the framework recommends that any energy modeling be approved by an accredited energy modeler.

- **Reporting of Performance Parameters.** Finally, the succes in implementing - and updating - the proposed framework will depend on thorough and organized data collection for benchmarking purposes within and outside the BPDA. Therefore, key performance attributes for each project are recommended to be collected and parsed into a database automatically. This should enable the design team and the BPDA to rely on benchmarking from other projects to follow a data-driven compliance process, particularly for unique buildings.

The consulting and City of Boston team that led to the recommendations hereby presented is comprised of members from the Boston Planning & Development Agency (BPDA), Thornton Tomasetti, and BR+A Consulting Engineers.

1.2 Framework

In coordination with the BPDA, it was determined that the framework of the recommendations for Zero Net Carbon zoning should be:

- Applicable to all building typologies
- Aligned with utility incentive and industry practice process, and therefore market-friendly
- Simple to review (relying on third party frameworks as much as possible)
- Align with upcoming BERDO 2.0 emissions performance standard
- In line with best-in-class new buildings in New England for performance targets
- Compatible with future updates to Mass. stretch code and new specialized code

1.3 Tag Process

In an effort to develop and refine the new framework for the City's ambitious goals, technical advisory groups (TAGs) were leveraged. Three TAGs were established: Low Carbon Buildings to establish emission targets and pathways, On-Site Renewable Energy for the on-site energy generation standard, and Renewable Energy Procurement to determine options and reporting.

This team's focus was the Low Carbon Building TAG. Four public meetings were held by the BDPA, Thornton Tomasetti, and BR+A between November 2020 and April 2021, with attendance from a group of experts. All meetings were recorded and are available on the BPDA's Zero Net Carbon Zoning webpage. The Low Carbon TAG meeting topics were as follows:

- Meeting 1: Framework and Pathways
- Meeting 2: Emissions Targets
- Meeting 3: Practice Transformation and Regulations
- Meeting 4: Finalizing Recommendations

After the first two meetings, the Low Carbon TAG was asked to complete two surveys on Pathways & Metrics and Pathways, Innovation, and Timing. The feedback from these surveys helped inform and shape the working group's decisions.

1.4 Precedents

Policy Precedents

An important piece of defining the pathway forward for Boston is to understand the approaches other cities have adopted. Some examples of cities that have already defined Zero Net Carbon / Low Carbon Buildings zoning policies or aggressive Climate Action Plans include:

- Local precedents: the city of Somerville is striving for all electric buildings and achieving LEED Platinum, prioritizing Passive House certification, as well as ILFI Zero Carbon certification through density and development bonuses. The city of Cambridge has a Net Zero Action Plan, while Brookline has a goal of Zero Emissions by 2050.
- Select cities have adopted a performance target approach. These cities are on the cutting edge and should be used to elevate and push the boundary in order to achieve carbon goals. Examples include but are not limited to the following:
    - Seattle has a "target performance path," with energy use intensity (EUI) targets for eight building typologies.
    - New York has adopted Local Law 97 in which there are carbon emissions intensity limits by building / space type, with fines for buildings that do not meet the minimum thresholds.
    - Toronto has a Zero Emissions Buildings Framework, with a full set of targets – total energy use intensity (TEUI), thermal energy demand intensity (TEDI), and greenhouse gas intensity (GHGI) – for the five most common building typologies.
    - London's Energy Transformation Initiative has EUI and whole life carbon targets for five building typologies, with more to be developed.
- Select cities either promote or require green building standards, such as LEED, LBC, or Passive House. Some of these cities allow Passive House buildings to be exempt from prescriptive requirements (San Francisco and Denver). Strategies employed to encourage Passive House include providing a PHIUS toolkit and training city staff.
- There is a focus in some areas on embodied carbon and concrete (including London, Marin County in California, and Portland, Oregon), but it is not yet the norm to require Life Cycle Analysis (LCA) reporting.

City of Boston Precedents

This set of recommendations builds on several other efforts undertaken by the city of Boston to meet its 2030 carbon neutrality goals. These include, notably:

- The City of Boston and the BPDA commissioned a study performed by the New Buildings Institute (NBI) to evaluate which building typologies should be targeted by the city to prescribe performance targets. The NBI's report, "Building Performance Targets and Building Prototype Profiles for Boston" dated February 27, 2020 proposes EUI targets for seven building typologies: 20-story High-Rise Apartment, Secondary School, Medium Office, Large Office, Large Hotel, and Laboratory. However, due to performance variability (schedules, plug loads, etc.), NBI recommends building performance targets for the following five typologies: 10-story High-Rise Apartment, 20-story High-Rise Apartment, Secondary School, Large Office, and Warehouse.
- The Net Zero Design Guidelines for the City's Department of Neighborhood Development, published in 2020, were developed in an effort to guide design teams in designing for a Zero Net Carbon affordable housing portfolio. Through a unique approach of establishing a "carbon budget" per resident (as opposed to per unit area, as is more typical), it was possible to set city-scale goals that would maximize on-site generation at a portfolio level, rather than building level.
- In 2013, Boston enacted the Building Energy Reporting and Disclosure Ordinance (BERDO), requiring large buildings to report their annual energy and water use to the City. In 2021, the ordinance was updated in its entirety to the Building Emissions Reduction and Disclosure Ordinance, which requires buildings over 20,000 sq ft or 15+ units to meet declining emissions standards and achieve net zero emissions by 2050.

2

SECTION 2

Recommendations

2.1 Building Performance Recommendations

The following recommendations apply, as requested by the BPDA, to buildings greater than 20,000 square feet. The calculations in the following pathway should not take any credit for renewable energy generation or procurement. Carbon conversion factors are included in Table 1.

The low carbon building metrics recommended in this report define reasonably attainable building carbon emissions performance standards only and do not include the benefits of onsite or offsite renewable energy, or renewable energy credits. We recommend that building carbon emission performance be demonstrated by predictive performance modeling at the earliest phases of project planning, at completion of construction documents, and confirmed at construction completion.

Recommended Performance Requirements

1. Carbon Emission Intensity (CEI) Target

The following building typologies must aim to meet the following CEI targets, using the carbon emission factors provided in Section 2.2 of this report. CEI based on year of occupancy grid emissions factors must also be reported.

Table 1: Recommended Carbon Emission Intensity Targets

Building Typology	CEI Targets [kg CO2e/sf] Recommended	All electric site EUI [kBtu/sf-yr] (for reference only)
Office	1.6	30
College / University Office	1.6	30
K-12 School	1.3	25
Hotel	1.9	35
Residence Hall	1.6	30
Low Density Multifamily	1.1	20
High Density Multifamily	1.6	30
Dry Lab	4.3	80
Wet Lab	6.4	120
Hospital	7.4	139

- Targets are calculated using predicted 2035 carbon emission factors for electricity of 52 kg/MMBtu as published in the BERDO technical methodology report.
- Projects that are composed of more than one listed building typology should use a target based on area weighted average.

  Note 1: The CEI performance targets assume some degree of mixed program. For example, lab buildings typically include both lab and office; in this case, an area-weighted average is not necessary. But, if a large portion of the building is dedicated to a second program type, such as a dedicated office tower above a lab/office podium, a weighted average of the office tower and lab podium should be calculated to define the CEI limit.

  Note 2: A lab building is defined as one that provides the mechanical infrastructure to support scientific research, including greater than or equal to 0.6 cfm/gsf of outdoor air capacity.

2. Percent Carbon Emissions Reduction

Additionally, projects of all typologies must meet a 40% carbon emissions reduction compared to ASHRAE Standard 90.1-2013 baseline except licensed healthcare facilities that are not medical office buildings, which should meet a 30% reduction. Calculations should be performed using the carbon emission factors provided in Section 2.2 of this report.

Note: Project teams may opt to use the Massachusetts stretch code baseline (ASHRAE Standard 90.1-2013 with MA amendments, including additional efficiency packages).

Allowable Alternatives:

1. Residential buildings that meet the below requirements:
    - Building does not trigger stretch code AND the total area of non-residential program does not exceed any of the following:
        - 50% of total GSF
        - 40,000 GSF
    - These buildings must:
        - Model HERS Index Score of < 38
        - Project use-specific CEI data for non-residential areas.

        Note: Residential program includes residential units and general circulation for residents; non-residential program is the gross area minus the residential program.
2. Buildings committed to achieving Passive House certification via PHIUS+ or PHI (WUFI Passive model must be provided as documentation).

It is recommended that renovations meet the 2035 BERDO existing carbon regulations for building typology, and can include renewables to do so.

Projects with unique conditions (e.g. schedules, loads, etc.) meeting the 40% carbon emissions reduction but not meeting the CEI target should have an opportunity to make a case for an adjusted value.

Phasing

It is recommended that the BPDA eventually offer a specific reduction threshold with respect to the current stretch code, based on data received throughout the zoning policy rollout. Note that the upcoming stretch code will be stricter than the current stretch code, so issuing a reduction threshold with respect to the new code is also recommended.

3. Rewarding Innovation / Exceptional Performance

Projects pursuing outstanding performance in low carbon building design (e.g. extraordinary levels of third party certification or industry-leading innovation) may be eligible for regulatory incentives (e.g. expedited review). These projects should have maximized on-site renewable energy generation.

For instance:

- Energy positive / zero energy buildings with 100%+ on-site renewables, including E+ Green Building Program
- PHIUS+ Source Zero
- Living Building Certification

Programs that allow projects to meet Zero Net Energy (ZNE) with off-site renewables are equivalent to ZNC requirement by the zoning policy and does not make these buildings "exceptional" in terms of performance.

4. Modeler Accreditation

Model results / report must be signed off by a P.E., Certified Energy Modeler, Certified Energy Manager, or BEMP.

5. Required Reporting

All project teams should also report the following values:

1. Envelope UA calculations (area weighted U-value)
   - Overall
   - Vertical envelope (excluding horizontal surfaces such as roof, slab-on-grade, etc.)
2. AHU energy recovery efficiency

   Weighted average exhaust air sensible energy recovery ratio for each HVAC system (sensible energy recovery ratio, per ASHRAE Standard 90.1-2019 definition)
3. Peak heating load:
   - Model breakdown (envelope, ventilation, infiltration, etc.)
   - Heating equipment system size per design
4. Carbon Emission Intensity (CEI), regardless of building typology
   - Using 2035 emissions
   - Using year of occupancy (City / BPDA to provide forecasted emission factors)
   - Buildings with multiple primary uses to provide typology-specific CEI (e.g. building that is 50% residential / 50% office)

2.2 Carbon Emission Factors

It is recommended that both Carbon Emission Intensity and Carbon Emission reductions shall be calculated and reported using both "occupancy year one" and 2035 electricity emission factors to more accurately represent the lifespan average emissions from buildings built in the near future, at a point where the ISO-NE grid electricty carbon emissions are predicted to be approximately equal to those of natural gas (2035 represents the 12.5-year mid-point of typical MEP system equipment lifespan (25-years) for a building built in 2022/2023).

Note: The working group considers that choosing 2035 as a target date is a conservative approximation of a greening grid that offers credit to utility-scale improvements in addition building-level efficiency measures.

It is recommended that the emission factors listed in Table 2 are used for all other emissions factors, to align with the BERDO program.

Table 2: Carbon Emission Factors

Fuel type	Emission factor (kg CO_2e/MMBtu)
Natural Gas	53.11
Fuel Oil (No. 1)	73.50
Fuel Oil (No. 2)	74.21
Fuel Oil (No. 4)	75.29
Diesel Oil	74.21
District Steam	66.40
District Hot Water	66.40
Electric Driven Chiller	52.70
Absorption Chiller using Natural Gas	73.89
Engine-Driven Chiller Natural Gas	49.31

Note:

1. For service in Boston, DOER has recently calculated the District Steam Emission Factor to be 87.54 kg CO2e/MMBtu
2. For Grid Electricity, the 2035 Emission Factor is 52 kg CO2e/MMBtu

Phasing

These carbon emission factors should be updated every 5 years (e.g. in 2025, it would be updated to the ISO-NE projected value for 2040), and as necessary to maintain alignment with the BERDO standards.

2.3 Leed Certification Recommendations

Based on the experience of neighboring communities, it is recommended that LEED Platinum Certification be required for both LEED v4 NC and LEED for Homes. The BPDA should consider LEED Gold for 20,000 - 50,000 sf, major renovations. Additionally, the following individual LEED credits must be targeted.

LEED NC

From a low carbon building standpoint, this working group recommends that the following credits be required:

- Integrative Design Process (IDP)
- Enhanced and Monitoring-Based Commissioning (Cx)
- Envelope Commissioning (BECx)
- Building Life Cycle Impact Reduction (LCA)
- Enhanced Refrigerant Management (if not meeting, document it)

It is anticipated that the following credits will be addressed by other TAGs:

- On-Site Renewable Energy Production (geothermal, solar PV)
- Renewable Energy Procurement (Green Power, RECs, Carbon Offsets)

LEED for Homes

- IPc1: Integrative Process
- ID: Innovation - Enhanced Commissioning

Note that BECx, LCA, and Enhanced Refrigerant Management do not exist in LEED for Homes

Phasing

It is recommended that the BPDA explore the possibility of including LEED NC Residential as a potential compliance path once the rating system is available in the US market.

2.4 Other Recommendations

Recommended that the BPDA:

- Develop a data collection / reporting system where metadata can be analyzed upon submission (Google forms, etc.).
- Utilize practice data to annually update performance thresholds and targets.
- Create case studies of exemplary projects and library of design strategies.
- Compile annual project filing report including a summary of key findings from submissions.

3

SECTION 3

Discussion

This section is intended to provide backrgound to the process followed to issue some of the key recommendations listed in Section 2 of this report.

3.1 Carbon Emission Intensity (Cei) Targets

Building Typology Selection

In order to meet Boston's 2050 carbon neutrality goals, it is key that all new buildings in the city be Zero Net Carbon. This is the basis for this working group recommending one performance pathway that can be applicable to all building typologies, and which is based on a percent reduction from ASHRAE Baselines. However, for those building typologies where the variability in performance is known to be small (e.g. office, multifamily housing, lodging, etc. - see Figure 1 below), there is an opportunity for the city to define absolute performance metrics such as Carbon Emissions Intensity (CEI). This is particularly relevant given the upcoming BERDO 2.0 carbon emission intensity performance thresholds.

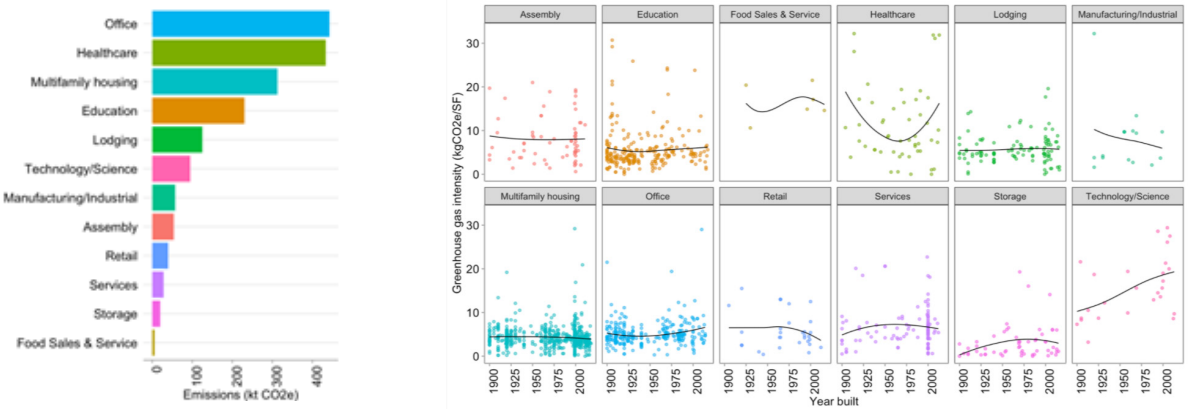


Figure 1. Total 2018 carbon emissions per building typology in Boston (left), Total carbon emissions per year of construction and per building typology (right). Source: Synapse model using BERDO data.

The building typologies proposed in this document's CEI performance were based on prioritizing the most carbon intensive typologies for the City, per BERDO data (see Figure 1, left): Office, Healthcare, Multifamily Housing, Education, Lodging and Technology/Science. As indicated in the NBI report, some of these typologies, such as office and housing are easy to benchmark given the low variability in their performance. However, others, such as Healthcare and Technology/Science, can have CEIs that vary widely dependent on program, and the choice to define an absolute performance threshold may seem inadequate. The working group opted to keep Laboratory buildings and Healthcare within the list of absolute thresholds based greatly on feedback from the Low Carbon Buildings Technical Advisory Group, as a way to define clear targets for most buildings within each typology (in particular Core ans Shell), with the option to document when a target is not being met and why.

Carbon Emission Thresholds

The proposed thresholds were defined based on average performance for best-in-class building performances in the Boston area, and were refined through benchmarking (Reference BE Plus report) and discussions with the Low Carbon Buildings TAG.

3.2 Percent Reduction In Emissions

Percent Reduction Threshold

A 40% reduction in carbon emissions with respect to ASHRAE Standard 90.1-2013 has been recommended as a requirement for all building typologies. The working group used data from the *Built Environment Plus - Massachusetts is Ready for Net Zero 2021 report,* along with feedbcak from the BPDA and the Low Carbon Building TAG to corroborate that such a threshold was reasonably strict. An analysis of more than 6 million square feet of new constrcution in Massachusetts (100+ buildings) indicated that a 40% reduction in carbon emissions is achievable for most building typologies (Figure 2). Most of these buildings were built at less than a 1% construction premium, which ensured that this threshold is not cost-prohibitive for owners.

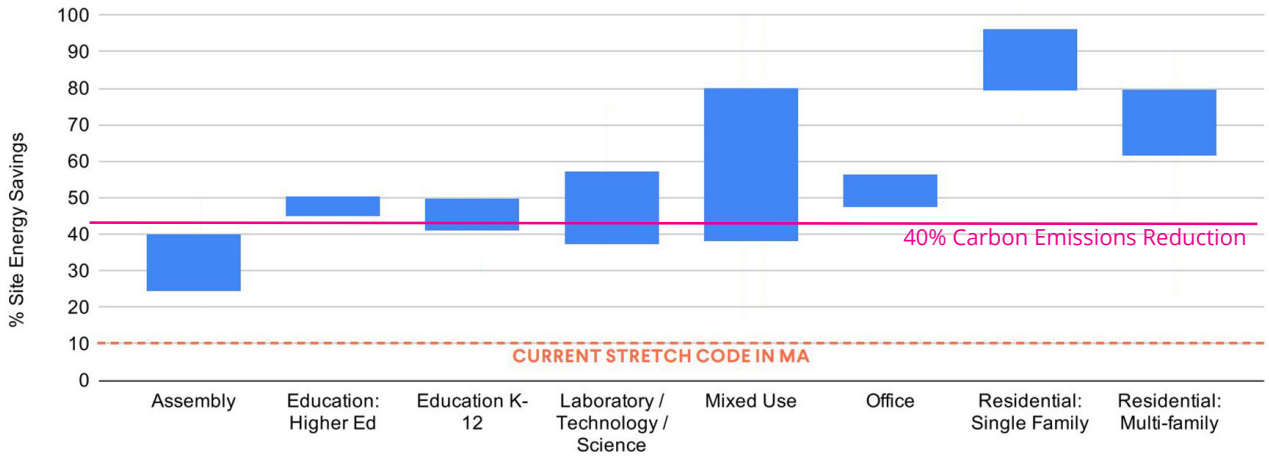


Figure 2: Percent Site Energy Savings with respect to ASHRAE Standard 90.1-2013 for 100+ MA buildings designed to be Net Zero Energy or Net Zero Ready, before discounting renewable neergy generation. Note that all buildings within the Assembly category are smaller than 20,000 sf and thus not applicable to the scope of this work. Bars represent those buildings falling in the 25th-75th percentile of reductions. Image adapted from Built Environment Plus - Massachusetts is Ready for Net Zero 2021 report.

Throughout the development of this document, it was brought to the working group's attention that many high performance Healthcare facilites (that are not medical office buildings) currently in construction would fail to meet the 40% threshold. A lower, 30%, threshold is thus recommended for that specific typology.

Modeling Baseline

The proposed energy modeling baseline to calculate carbon emission reductions is ASHRAE Standard 90.1-2013, which is the baseline that the working group had the most data to utilize in benchmarking. Teams working on buildings of outstanding performance where the percent reduction with respect to current Stretch Code in MA exceeds the required 40% can opt to use this more stringent baseline to avoid generating an additional model.

4

SECTION 4

Closing / Future Work

4.1 Closing / Future Considerations

This report is intended to be the consolidation of continued TAG meetings as well documentation for formal approval by the City of Boston. While the team feels there are important next steps to continue the development of policy in Boston, the author's hope is that this document can serve as a framework for officially-sanctioned policy.

Future recommended considerations include:

- On a regular basis, review policy benchmarks and emissions factors to confirm policy is current with best practice.
- Consider incroporating hourly carbon emissions factors taking into consideration daily and seasonal variations, in order to incorporate demand response strategies into policy framework.
- Strive to include within the Zero Net Carbon zoning polocy buildings below 20,000 square feet.
- Consider opportunities for coordinated data collection and reporting between Article 37 and BERDO to create a consistent workflow, enabling the BPDA and the public to study the links between predicted and actual performance.

Appendix III:

Boston Zero Net Carbon Renewable Energy Technical Advisory Group Report

Prepared for:
The City of Boston / Boston Planning & Development Agency

Prepared by:
CADMUS Group

Contents

This report summarizes the findings and recommendations of the Cadmus Group based on our work with the On-Site Renewable Energy Technical Advisory Groups (TAG) in support of Boston's Zero Net Carbon Building Zoning Initiative. The report is organized into four sections: I. Introduction and Background, II. Recommendations, III. Financial Analysis, and IV. Additional Considerations. Appendix 1 provides additional resources related to solar photovoltaic (PV) system ownership models, financing, and incentives.

Introduction and Background

In September 2020, The Boston Planning and Development Agency (BPDA) launched their Zero Net Carbon Building (ZNC) Zoning Initiative seeking to develop to a zero net carbon standard for new construction as a step toward the City's goal of carbon neutrality by 2050. To support this effort, the BPDA created four TAGs: Low Carbon Building, On-Site Renewable Energy, Renewable Energy Procurement, and Embodied Carbon.

The On-Site Renewable Energy TAG was facilitated by BPDA with support from Cadmus. The TAG consisted of 12 members, including representation from the development sector, solar developers, planning and architecture, and engagement of five City staff. Three TAG meetings were held, focusing on 1) initial scoping and strategy, 2) development of recommendations, and 3) review of recommendations and financial analysis. This report summarizes the input and discussion of the TAG and the recommendations that emerged from these discussions.

Context

The City of Boston has long been a leader in solar energy and green buildings. The City first adopted Article 37 in the Zoning Code in 2007 requiring high performance, sustainable building practices in accordance with US Green Building Council Leadership in Environmental and Energy Design (LEED) Rating System(s). The City has also adopted the Massachusetts Stretch Code, which requires designation of a solar ready zone and preparation for electrical interconnection (but does not require installation of the solar energy system).

There is existing precedent in Massachusetts for requiring the installation of solar PV for new construction through municipal zoning. The City of Watertown Zoning Ordinance (Section 8.05, as amended December 11, 2018) requires development undergoing site plan review approval under Section 9.03 (Site Plan Review of Certain Residential and Non-Residential Developments) that is greater than 10,000 gross square feet "shall include a solar energy system that is equivalent to a minimum of 50% of the roof area of all buildings. In cases where a site includes an uncovered parking structure, the structure shall also have a solar energy system installed to cover a minimum of 90% of its top level." There are also numerous cities across the United States that now mandate solar energy installations, including San Francisco, Santa Monica, CA and South Miami, FL.

Recommendations

The On-Site Renewable Energy TAG developed the following goals to guide the development of the on-site generation portion of the ZNC policy:

» To ensure ZNC buildings reduce carbon emission through the use of on-site renewable energy resources by establishing minimum standards for installation of on-site renewable energy systems;

» To reward innovation;
» To maximize the deployment of renewable energy in the City of Boston in order to fully realize the benefits of local energy generation (i.e., resilience, jobs, air quality, grid services); and
» To ensure accountability and transparency in compliance with ZNC Regulations.

Furthermore, the TAG sought to ensure that ZNC Zoning requirements for on-site generation maximize the benefits of local generation, including:

» Emission Reductions
» Electric Grid Management
» Local Job & Business Creation
» Public Health
» Resilience

In addition, the group also recognized the following project aspects:

» Physical feasibility: shading, roof uses, setbacks/access
» Regulatory feasibility: utility interconnection, zoning code, building code
» Financial feasibility: costs, incentives, credit, electricity rates, and ownership models

To these goals, the TAG developed the following recommendations:

01. Net Zero Carbon buildings should optimize on-site renewable energy production. ZNC buildings should be planned and designed to go beyond "solar ready" and instead be "solar optimized." This means that the opportunity for solar is considered in the earliest stages of project design and that design decisions are made to maximize the capacity and performance of solar PV on rooftops, integrated in building structures, and ground-mount canopies. Solar optimization and building and urban design options and priorities are to be equally considered. The installation of the solar PV should be complete as part of project construction and is a requirement for occupancy.

To best realize opportunities for solar, the City should engage project teams at the earliest stages of project planning and require building designs to:

» Maximize south-facing solar opportunities on building roofs, facades, and sites
» Layout roof to maximize space free of obstructions (including minor MEP)
» Consolidate mechanicals equipment and vents;
» Consider complementary uses (solar as shading for roof decks); and
» Avoid roof forms and slopes unsuitable for solar energy systems.

01. Define a Minimum Area for Solar. While the goal is to optimize the amount of solar installed at each ZNC building, in order to ensure that all buildings are integrating solar, the TAG recommends defining a minimum area for solar in the design process. They recommend the minimum area is 50% of the building roof that is flat or oriented between 110 and 270 degrees of true north, 90% of the top level if that is open, and 50% of surface parking.
02. Allow participation in the SMART Program. Recognizing the importance of new local renewable energy systems to Boston's carbon neutral goals and that the Solar Massachusetts Renewable Target (SMART)

Program is important to the financial feasibility of many solar energy installations the TAG recommends that ZNC buildings are allowed to participate in the SMART Program. However, because the SMART program retains the related RECs for the public utilities the ZNC code will need to provide guidance related to SMART Program participation and energy/carbon accounting. This is a concept that is likely to need additional consideration as the City develops the final policy language and may require legal review. It is important to be clear about REC ownership and who is taking credit for renewable energy. The TAG suggested that the City develop a definition of "SMART Energy" and allow ZNC buildings to comply with on-site requirements using "SMART Energy." By enabling participation in the SMART program, the City could help to incentivize local generation and enable projects to be more financially viable. Section III provides two financial case studies that further illustrate the importance of the SMART Program on project finances.

Draft definition of "SMART Energy": Solar Energy generated at a ZNC Building by where RECs are not owned by the building owner due to participation in SMART program.

Financial Considerations: Case Studies

In the section below, Cadmus aims to demonstrate how the ZNC would affect project finances through two illustrative case studies: a representative lab building and a multi-family home in Boston. The Cadmus team worked with the On-Site Renewable Energy TAG to select the representative building types. Cadmus then modeled the design and estimated output of potential solar PV systems atop the two representative buildings using Helioscope, a web-based PV design software.[01] The theoretical feasibility assessment detailed in this section includes both a technical analysis and an economic analysis of the priority sites. The technical analysis outlines the potential sizes of PV systems and annual electricity generation. The economic analysis includes an estimated cost of the systems; financing and contract options; and payback and return on investment scenarios generated using NREL's System Advisor Model (SAM).[02]

Technical Case Study Overview

The estimated annual solar PV production offered in this analysis can be used to project annual energy savings for building owners under the proposed ZNC. We would expect site-specific energy savings to continue over a 25-year timeline with minimal (approximately 0.8%) annual performance degradation. For each design below, Cadmus maintained reasonable and consistent technology assumptions, including the use of 370-Watt panels and inverters optimized to produce accurate PV generation estimates. As designed, the PV systems depicted below also ensure that no roof-mounted solar PV system would cause the shedding of ice or snow from the roof into a porch, stairwell, or pedestrian travel area. Cadmus ensured these safety requirements were met by incorporating setbacks and access pathways that exceeded the minimum requirements as defined in the National Fire Protection Association Fire Code.[03] In the depiction of each solar PV design, each blue rectangle represents a single PV module. Orange-shaded areas represent locations where solar PV was not "installed", due to the safety requirements mentioned above, or obstructions like mechanical equipment, access pathways, and stairwells.

01 Helioscope is a cloud-based solar photovoltaic design modeling software that integrates system design and performance modeling to develop preliminary layouts and energy yield calculations for measuring solar PV feasibility

02 National Renewable Energy Laboratory (NREL). System Advisor Model. https://sam.nrel.gov/

03 National Fire Protection Association (NFPA) 1, 2015. Section 11.12 Photovoltaic Systems. https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1

Financial Case Study Overview

For the purposes of this financial analysis, both the representative lab building, and the multi-family home were modeled under two direct-ownership scenarios: (1) Direct Ownership without enrollment in the SMART program, which would enable the building owner to retain the RECs generated by their system, and (2) Direct Ownership with enrollment in the SMART program, which sacrifices retention of the system's RECs but provides additional financial return via the SMART program. Each case study was also modeled under a Third-Party Ownership (TPO) scenario, whereby the site host would enter into a power purchase agreement (PPA) with the owner. Under a PPA, Cadmus assumed the developer would require that the PV system is enrolled in the SMART program. Additional details on ownership, financing, and incentives are provided in Appendix 1.

It is important to note that for the ZNC buildings modeled, Cadmus is not comparing the return on investment of solar PV to the option of "doing nothing." All ZNC buildings will be mandated to generate or buy 100% of their energy from renewable energy resources, and the projections below reflect that assumption. [04] For the purpose of this analysis, Cadmus has not factored in the potential reduction of demand charges from solar PV, as it's difficult to predict when a net zero building will experience peak load. The basic financial assumptions used for both the Lab and MFH case study scenarios are summarized in Table 1.

Table 1. Financial Analysis Inputs

Input	Estimated Values
Project Lifetime (years)	25
Energy Yield Ratio (kW/kWh)	1,131
Electricity Bill Escalation Rate	1.5%
Federal Investment Tax Credit (ITC)	26%
Loan to Value Ratio	53.8%
Annual Interest Rate	6.1%
Debt Tenor (years)	10
Inverter Replacement Cost in Year 13 ($/Watt)	$0.30
Decommissioning in Year 25 ($/Watt)	$0.30
Annual O&M Cost ($/kW)	$20.00

Note: that for the purposes of the financial analyses below, Cadmus assumed the commercial entities owning the solar PV systems are able to utilize 100% of the state and federal tax benefits for which they are eligible. [05]

04 Both case studies' basic service rate for electricity was estimated using the 100% Green Electricity offering via the City of Boston's Community Choice Electricity program. The value of energy was calculated by adding the expected transmission, transition, and distribution charges to the estimated basic service rate for each building type. City of Boston. Community Choice Electricity. https://www.boston.gov/departments/environment/community-choice-electricity

05 This is important to note, because a bank may view these projects as over leveraged given the financing assumptions modeled. As demonstrated in the cash flows depicted in Figure 2 and Figure 4, for example, setting the debt tenor at 10 years may be creating a debt burden that is too high, i.e., cash flows available to service the debt may not be sufficient. Longer-term debt financing may be more beneficial.

Case Study 1: Lab

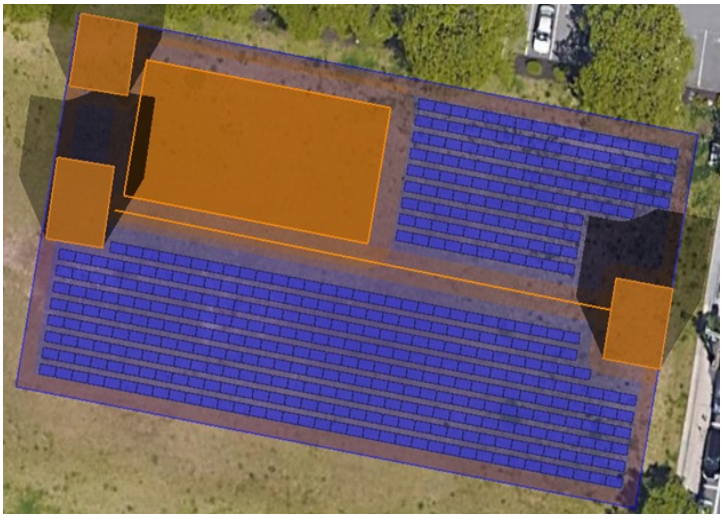
The representative lab building modeled was designed to demonstrate the technical and financial feasibility of a solar PV project at a large commercial building in Boston. It was estimated that a commercial lab building of this size would have an estimated monthly electricity load of 579,719 kWh, with total annual demand just below 6,957,000 kWh. Informed by the lab building's electricity use profile, Cadmus assumed the utility rates and SMART incentive payments listed in Table 2 below.

Table 2. Lab Building Rates and Incentives

Input	Estimated Lab Value
Average Monthly Usage	579,719 kWh
Estimate Annual Usage	6,956,626 kWh
100% Green Basic Service Rate	$0.1426/kWh
Value of Energy (VOE)	$0.1506/kWh
SMART Incentive Payment	0.1233/kWh

As designed, the lab building modeled is 180 feet tall, with a total building area of 316,500 sq. ft. and a roof area of 25,816 sq. ft. (120 ft. X 215 ft.). The lab building is set back from the nearest street and abutting property line by at least 15 ft. The solar PV system designed at the representative lab building covers an estimated 13,544 sq. ft., or about 52% of the total roof area, in-line with the 50% coverage requirement detailed in the proposed ZNC. As designed, the solar PV system at the lab building would have a 159.8 kW-DC capacity, enough to generate 180,000 kWh for year 1, which represents 2.6% of total estimated on-site electricity load.

Figure 1. Potential Solar PV Design at Representative Lab Building



System Specifications

PV System Area: ..... 13,544 sq. ft.
Roof Area/PV Area: 52%
PV System Capacity (kW-DC)..... 159.8
PV System Capacity (kW-AC) 125.3
Azimuth: ..... 190°
Annual PV Generation (kWh): 180,000
Annual Load Offset: 2.6%
Installed Cost ($2.50/W): $399,500
Panels: 432

Financial Analysis: Lab

Cadmus' financial analysis indicates that the solar PV system at the representative lab building is cost effective under both direct-ownership scenarios evaluated, in addition to the PPA scenario modeled. When enrolled in the SMART program, the solar PV system generated an internal rate of return (IRR) of about 25%, while the solar PV system without enrollment in the SMART program had an IRR of 5% under a direct ownership model. Under the PPA scenario modeled, the developer's IRR for the project came to an estimated 18%. The PPA scenario assumes enrollment in the SMART program and a 15% discount rate on electricity for the offtaker. Cadmus assumed a solar PV install cost of $2.50/Watt for this system.

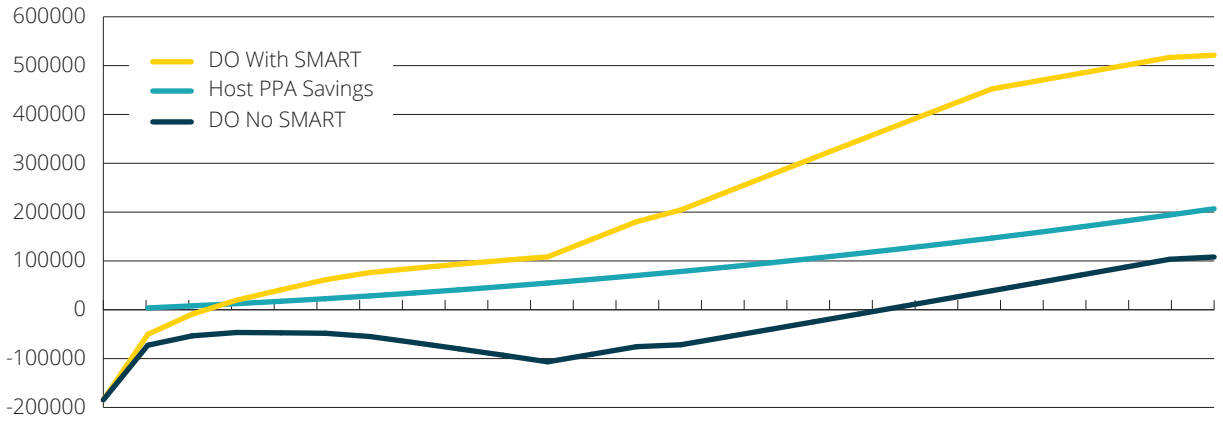
Table 3. Lab Building Direct Ownership Financial Analysis Outputs

Ownership Scenario	Total Capital Install Cost	Value of Federal ITC	Year 1 Avoided Electricity Cost	Year 1 SMART Solar Incentive Payment	25-Year Cumulative After-Tax Cash Flow	Project IRR
Direct Ownership (w/o SMART)	$399,500	$103,870	$27,200	$0	$108,030	5%
Direct Ownership (w/ SMART)	$399,500	$103,870	$27,200	$22,280	$521,325	25%

Table 4. Lab Building Third-Party Ownership Financial Analysis Outputs

Ownership Scenario	Annual Electricity Usage Offset by PV	Utility VOE ($/kWh)	Year 1 PPA Rate (15% Discount)	Est. Annual PPA Savings	Project Owner IRR
PPA (w/ SMART)	180,000	$0.1506	$0.1296	$3,800	18%

Figure 2. Lab Scenario 25-Year Value to Building Owner



As shown in Figure 2, all three ownership scenarios modeled for the representative lab building generate economic value to the building-owner over the 25-year project lifetime. Note that in Figure 2, value to the building owner reflects cumulative after-tax cash flow for both direct ownership scenarios and expected electricity savings for the PPA scenario modeled. The direct ownership scenario with enrollment in the SMART program (orange line) produces maximum benefit to the building owner, producing an estimated 25-year after-tax cashflow of over $500,000. If the system is owned directly and foregoes the SMART incentive (blue line), then cumulative after-tax cashflow over the project lifetime is expected to decrease from an estimated $500,000 down to just over $100,000. This decrease in value is a result of the project sacrificing the $0.123/kWh SMART incentive for the estimated 180,000 kWh the system would produce annually, though it would allow for the building owner to retain the project's RECs.

Under the 15% fixed discount PPA rate scenario, represented by the gray line, the building owner would generate an estimated $200,000 in savings over the project lifetime. Unlike the direct ownership options evaluated, a PPA does not require any upfront investment from the building owner. Instead, the building owner benefits from an immediate 15% savings on their electricity bill for the energy their system produces, equivalent to the PPA discount rate. In year 1, PPA savings to the building owner are expected to be approximately $3,800.

Case Study 2: Multi-Family Housing (MFH)

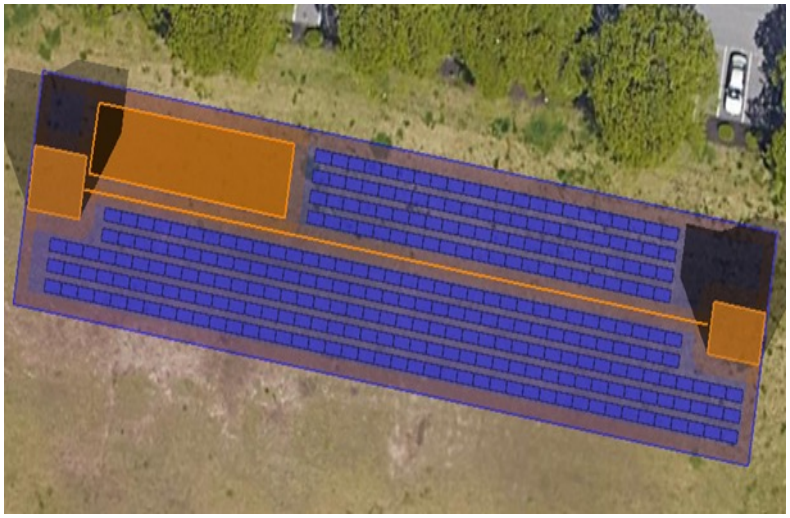
The representative multi-family residential building modeled was designed to specifications provided by the On-Site Renewable Energy TAG and was selected to demonstrate the technical and financial feasibility of a solar PV project at a multi-family building in Boston. It was estimated that a MFH of this size would have a monthly electricity load of 71,280 kWh, with total annual demand just over 855,000 kWh. Informed by the MFH's electricity use profile, Cadmus assumed the utility rates and SMART incentive payments listed in Table 5 below.

Table 5. MFH Rates and Incentives

Ownership Scenario	Total Capital Install Cost	Value of Federal ITC	Year 1 Avoided Electricity Cost	Year 1 SMART Solar Incentive Payment	25-Year Cumulative After-tax Cash Flow	Project IRR
Direct Ownership (w/o SMART)	$262,750	$68,315	$23,160	$0	$162,137	10%
Direct Ownership (w/SMART)	$262,750	$68,315	$23,160	$9,380	$336,260	23%

As designed, the MFH modeled is 84 feet tall, with a total building area of 97,290 sq. ft. and a roof area of 15,085 sq. ft. (60.2 ft. X 250.4 ft.). The MFH is set back from the nearest street and abutting property line by at least 25 ft. The solar PV system designed at the representative MFH covers an estimated 8,078 sq. ft., or about 54% of the total roof area, in-line with the 50% coverage requirement detailed in the proposed ZNC. As designed, the solar PV system at the MFH would have a 105.1 kW-DC capacity, enough to generate 118,000 kWh annually or 14% of total estimated on-site electricity load.

Figure 3. Potential Solar PV Design at Representative Multi-Family Home



System Specifications

PV System Area: ..... 13,544 ft^2
Roof Area/PV Area: 52%
PV System Capacity (kW-DC)... 159.8
PV System Capacity (kW-AC) ... 125.3
Azimuth: ..... 190°
Annual PV Generation (kWh) .. 180,000
Annual Load Offset 2.6%
Installed Cost ($2.50/W): $399,500
Panels: 432

Financial Analysis: MFH

Cadmus' financial analysis indicates that the solar PV system at the representative MFH is cost effective under either direct ownership scenario evaluated, in addition to the PPA scenario modeled. When owned directly and enrolled in the SMART program, the solar PV system generated an internal rate of return (IRR) of about 23%, while the solar PV system without enrollment in the SMART program had an IRR of 10%. Under the PPA scenario modeled, the developer's IRR for the project came to an estimated 14%. The PPA scenario assumes enrollment in the SMART program and a 15% discount rate on electricity for the offtaker. Cadmus assumed a solar PV install cost of $2.50/Watt for this system.

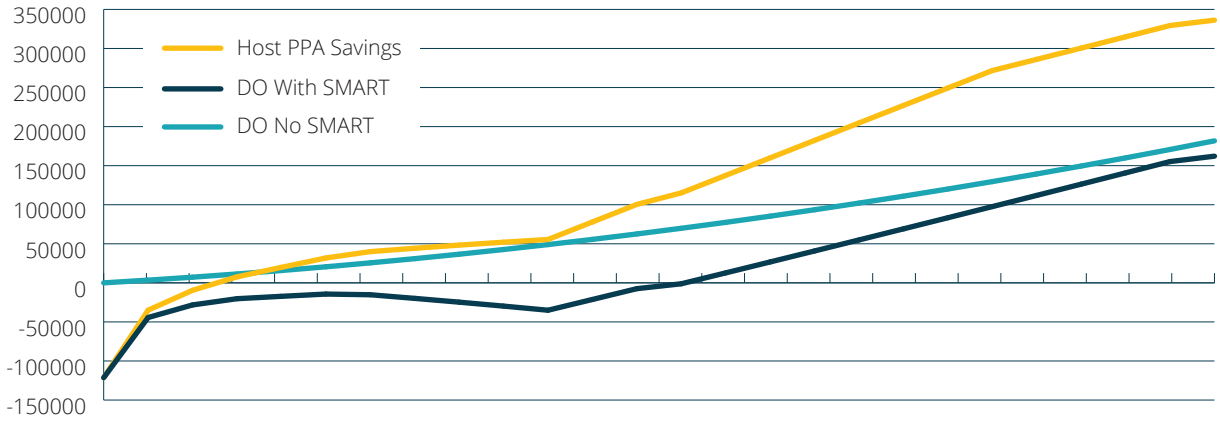
Table 6. Multi-Family Home Direct Ownership Financial Analysis Outputs

Ownership Scenario	Total Capital Install Cost	Value of Federal ITC	Year 1 Avoided Electricity Cost	Year 1 SMART Solar Incentive Payment	25-Year Cumulative After-tax Cash Flow	Project IRR
Direct Ownership (w/o SMART)	$262,750	$68,315	$23,160	$0	$162,137	10%
Direct Ownership (w/SMART)	$262,750	$68,315	$23,160	$9,380	$336,260	23%

Table 7. Multi-Family Home Third-Party Ownership Financial Analysis Outputs

Ownership Scenario	Annual Electricity Usage Offset by PV	Utility VOE ($/kWh)	Year 1 PPA Rate (15% discount)	Est. Annual PPA Savings	Project Owner IRR
PPA (w/ SMART)	118,000	$0.1949	$0.1657	$3,475	14%

Figure 4. MFH Scenario 25-Year Value to Building Owner



Similar to the lab building, all three ownership scenarios modeled for the representative MFH building generate economic value to the building-owner over the 25-year project lifetime. Note that in Figure 4, value to the building owner reflects cumulative after-tax cash flow for both direct ownership scenarios and expected electricity savings for the PPA scenario modeled. The direct ownership scenario with enrollment in the SMART program (orange line) produces maximum benefit to the building owner, producing an estimated 25-year cumulative, after-tax cashflow of over $330,000. If the system is owned directly and foregoes the SMART incentive (blue line), then cumulative after-tax cashflow over the project lifetime is expected to decrease approximately 50%. This decrease in value is a result of the project sacrificing the $0.079/kWh SMART incentive for the estimated 118,000 kWh the system would produce annually, though it would allow for the building owner to retain the project's RECs.

Under the 15% fixed discount PPA rate scenario, represented by the gray line, the building owner would generate an estimated $180,000 in savings over the project lifetime. Unlike the direct ownership options evaluated, a PPA does not require any upfront investment from the building owner. Instead, the building owner benefits from an immediate 15% savings on their electricity bill for the energy their system produces, equivalent to the PPA discount rate. In year 1, PPA savings to the building owner are expected to be approximately $3,750.

The intention of these two illustrative case studies is to show the current technical and financial viability of on-site renewable energy in Boston under the proposed ZNC. As the market for solar PV and other renewable energy resources continue to mature, it is anticipated that project financing opportunities, cost declines, and technology improvements will further improve the financial prospects of renewable energy procurement in the City. Additionally, Boston building owners with on-site renewable energy generation will also be insulated to some extent from electricity cost increases, which Cadmus assumes will continue to rise 1.5% annually.

Additional Details and Considerations

To support solar optimization on ZNC buildings, the TAG recommends a process by which applicants identify the "Solar Zone" which effectively identifies the maximum area available for solar (below is guidance on specific exceptions and exclusions for areas that may reduce the size of the Solar Zone). The Solar Zone should be considered throughout the design and construction process and decisions should be made that reduce potential conflicts and avoid obstructions and intrusions on the Solar Zone. The City should also adopt a Minimum Solar Requirement (further guidance below). The applicant must meet the minimum solar requirement as a condition of building occupancy. This approach is intended to support solar optimization – encouraging project design and decision-making that will maximize solar opportunities- while also providing a clear and enforceable minimum solar standard. The following provides additional details and related definitions and process guidance.

Proposed Minimum Solar Requirement

The On-Site Renewable Energy TAG proposes that a ZNC Building should be planned, designed, engineered, and constructed with a Solar Energy System(s) equal to but not less than:

- 50% of the building roof area(s) that is either flat or oriented between 110 degrees and 270 degrees of true north
- 90% of the parking structure deck(s) uncovered
- 50% of the surface parking area(s)
- Less area reductions due to Solar Exemptions and Solar Exclusions

Physical Exceptions

The following conditions may allow the required Solar Zone(s) to be partially or entirely reduced in size:

- Roof areas where building mechanical and structural systems restrict the available Solar Zone(s).
- Roof, building, and ground plane areas where the Solar Zone(s) is shaded for more than 50 percent of daylight hours annually.
- The total Solar Energy System(s) of a project need not exceed 120% of the annual energy loads of the project.

» Historic Building Preservation or similar Design Overlay District requirements including standards for additional setbacks or other aesthetic exceptions as determined by the Historic Preservation Commission and BPDA Urban Design.

Exclusions

» The Solar Zone(s) may be reduced in size or modified in configuration to accommodate mandatory access and set back areas required by relevant historic preservation, building, and fire codes and regulations.
» The Solar Energy System(s) may be partially or entirely restricted in energy output due to utility electrical distribution system constraints.*
» Solar Energy Systems shall be configured and located so as to ensure the following:
  - Provision of emergency access pathways to and from the roof(s) and roof area(s) required for smoke ventilation as required by building and fire codes. 527 CMR.
  - Snow and ice does not shed into unprotected pedestrian travel area(s).

Proposed Process & Submittals

As part of the BPDA Urban Design and Article 37 Review process projects would provide plans, diagrams, descriptions, and analysis to demonstrate that the Proposed Project has optimized the potential for solar energy production, identified the maximum Solar Zone(s), is planned, designed, and engineered to support the proposed system(s), and that the Solar Energy System(s) is installed and fully operational at construction completion:

» Site and building plans illustrating the maximum feasible Solar Zone(s) for all structures and all ground plane areas including details on any Solar Exceptions, Solar Exclusions, and Electrical Energy Restrictions.
» Solar Energy System(s) description including layout, configuration, system type, size, energy output, controls, storage, and ownership model.
» Post installation Solar Energy System(s) commissioning reports and certificates.
» Other related information deemed supportive or necessary to understanding project and system planning, design, and installation.

Consider a Grace Period

Recognizing that solar incentives, financing, utility interconnection and other issues can impact project timing (and that the City prioritizes on-site generation and is willing to provide some flexibility on timing to overcome these challenges), the TAG recommends the City consider offering a grace period up to 12-months for the installation of solar. During this period, the ZNC building should be required to purchase renewable energy from off-site sources. Projects should be strongly encouraged to complete the installation of solar prior to occupancy, and the City could define a discrete set of circumstances that limit the frequency of granting the use of the grace period and require applicants identify the specific technical or financial constraint that can be resolved within the 12-month period.

Financial Feasibility

As indicated in the financial case studies herein, solar can create economic value and positive cash flow on a variety of project types under today's conditions. As the costs of solar continue to come down, this is likely to be true for an increasing number of projects. By allowing applicants to comply with the on-site requirements through different ownership models and by allowing SMART Program participation, the City is helping to maximize the potential financial returns and enable flexibility. However, every owner has different financial goals and may differ in their access to capital, risk aversion, etc. and the TAG does not recommend that the City define financial feasibility criteria. The City can continue to help educate the development community by publishing case studies and showing how different ownership and financial models are being used to maximize the economic value of on-site solar.

Definitions

Related to the development and installation of On-Site Renewable Energy Generation, the TAG considered and discussed several concepts that require definitions. The following definitions are recommended:

On-Site Generation: On-site renewable energy is located on:

- The building,
- The property upon which the building is located,
- A property that shares a boundary with and is under the same ownership or control as the property on which the building is located, or
- A property that is under the same ownership or control as the property on which the building is located and is separated only by a public right-of-way on which the building is located.

SMART Energy: Solar Energy generated at a ZNC Building by where RECs are not owned by the building owner due to participation in SMART program.

Solar Zone: the building and site area(s) suitable for the Solar Energy System(s)

Appendix 1. Additional Information on Solar Ownership Models, Financing and Incentives

System Ownership Options and Financing

Direct Ownership

This is when the property owner purchases the solar PV system from the installer. Direct ownership normally allows the property owner to collect all eligible federal and state tax benefits, utilize state and local financial incentives, and use the electricity generated by the system.

Third-Party Ownership

The solar installer or a financing partner owns the solar PV system on the municipal property and is responsible for operations and maintenance. The third-party partner collects the tax benefits and financial incentives, including the Federal Investment Tax Credit (ITC), and passes a share of the savings on to the

electricity buyer, usually in the form of lower energy costs. Under third-party ownership, there are several options for the property owner to benefit from the solar electric system, the most common of which is a power purchase agreement (PPA). A PPA is an agreement between the energy off-taker and the third-party system owner. The system owner sells the electricity produced by the system to the off-taker at a predictable fixed price per kilowatt hour. The electricity price under a PPA is typically lower than the standard utility price of electricity, so the off-taker receives immediate savings through reduced energy costs. Non-profits often utilize this scheme, because the participant is not responsible for the upfront capital cost of the system or operations and management.

Other third-party ownership options include a site lease agreement between a property owner and solar installer (or a third party) in which the third-party builds, owns, and operates a solar electric system on a host site. The property owner will receive benefits in the form of site lease payments from the third-party. This may be paired with a PPA with the property owner, or the developer may elect to sell the electricity to a utility or another entity. A production guarantee is often included if paired with a PPA, or structured as the leasing of the equipment. Another more complicated option under third-party ownership is the use of a tax equity financing partner, whereby a third-party investor takes passive ownership to receive the tax benefits and cash return on investment. This model in some ways blends the ownership options and may be an option for property owners who favor direct ownership, but don't have the tax liability needed to utilize the federal incentive.

Incentives and Benefits

Massachusetts State Incentives

Massachusetts offers incentives for grid-connected solar projects in investor-owned utility service territories (Eversource, and other MA utilities) through the Solar Massachusetts Renewable Energy Target (SMART) program. The SMART program provides solar PV system owners with incentives for renewable energy production. Organizations that own the solar electric system will receive the incentive benefit directly, while organizations that opt for third-party ownership will receive the incentive indirectly via the negotiated PPA or lease price. The program provides solar projects an incentive payment in exchange for the environmental attributes of the solar power. The program also contains an array of "adders" which can increase or decrease the incentive payment by project based on its desirability to the state (e.g. large ground-mounted projects are discouraged, and brownfield sites are encouraged). Adder amounts vary and are categorized by location type (e.g. roof, ground), off-taker type (e.g. governmental, low-moderate-income) and energy storage. The program has a declining block framework, so as more projects come online, and a capacity block fills, the incentive levels decline in an effort to mirror forecasted cost declines for the technology. Projects larger than 25 kW-AC receive a 20-year fixed incentive rate determined at the time of application approval, while smaller projects receive a 10-year fixed incentive. The incentive program has been adjusted multiple times throughout its existence and is likely to be modified in the medium-term as the boom in solar installations continue. It is important to note that any solar PV project in Massachusetts that takes advantage of the financial benefits of the SMART program, regardless of ownership option pursued, relinquishes the environmental attributes or renewable energy certificates (RECs) ascribed to the energy their system produces.

Net Metering and Alternative On-Bill Credits

Net metering is the Massachusetts policy that enables owners of solar PV systems to receive monetary credit on their electricity bill for electricity produced by the system and sent to the grid. Bill credits are based on the net energy usage of a facility with solar generation within a given month. The value of these credits varies depending on the size of the solar electric system. See Mass.gov's Net Metering Guide for more information

and current rates. An alternative to net metering, Alternative On-Bill Credits (AOBCs) can be monetized by facilities that qualify for the SMART program and are otherwise unable to take advantage of net metering. AOBCs allow bill credits to be transferred across customer accounts, though at a reduced rate compared to net metered systems.

Virtual Net Metering

Virtual Net Metering, also known as a Net Metering Credit Purchase Agreement (NMCPA), functions almost identically to net metering, but introduces a third-party. Under a virtual net metering scenario, a developer builds an off-site solar PV array and the electricity produced by the solar PV array is applied to the off-taker's electric bills in the form of a credit via the utility. Virtual net metering can be a useful tool for those that wish to offset their electricity usage with clean energy, but do not have adequate space to install on-site renewables at the facilities they own. Under this scenario, the developer bills the off-taker separately for credits applied to their electric bills and the off-taker saves money annually by paying less for electricity than they currently pay to the utility. Massachusetts does not differentiate between behind-the-meter net metering (electricity generation consumed on the same site it is generated) versus virtual net metering (electricity generation consumed at a site other than where the electricity is generated). For most purposes, including credit calculation, there is no difference between net metering and virtual net metering. If you allocate net metering credits to a public entity, there is no effect on the public entity's 10 MW limit for net metering, and a public entity may receive an unlimited amount of net metering credits with no effect on its 10 MW limit. The capacity of a net metering facility within the public cap only affects the host customer's 10 MW limit.

Federal Investment Tax Credit (ITC)

Solar PV projects are typically eligible for the Federal Investment Tax Credit (ITC), which allows the owner to receive a one-time tax credit on federal taxes equal to a percentage of the project cost (per Section 48 of the Internal Revenue Code). In late 2020, the ITC step-down schedule was pushed out as part of COVID-relief: projects beginning construction through the end of 2022 will be eligible for a 26% credit; the credit declines to 22% for 2023 and then drops down to 10% thereafter. (Note: non-profit projects would only be able to realize savings associated with the ITC if they partner with a private third-party that is eligible.) Generally, solar PV and energy storage systems also qualify for five-year Modified Accelerated Cost-Recovery System (MACRS) depreciation schedule. The Tax Cuts and Jobs Act of 2017, however, allows for 100% bonus depreciation (in year one) for solar projects through the end of 2022. The rate steps down by 20 percentage points each year thereafter (i.e., 80% in 2023, 60% in 2024, etc.).

Appendix IV:

Boston Zero Net Carbon: Renewable Energy Procurement Technical Advisory Group Report

Prepared for:
The City of Boston / Boston Planning & Development Agency

Prepared by:
Erin McDade, Senior Program Director
Charles Eley, Senior Fellow, and
Vincent Martinez, Chief Operating Officer

Architecture 2030
2030, Inc. / Architecture 2030
architecture2030.org

Contents

Introduction

The City of Boston is considering renewable energy procurement as a requirement for the City. Buildings proposed to be constructed would be required to install on-site renewable energy and/or procure off-site renewable energy. The requirement is intended to offset building energy use and achieve zero-net carbon.

In September 2020, The Boston Planning and Development Agency (BPDA) launched their Zero Net Carbon Building Zoning Initiative (ZNC Zoning) "in order to assess and identify strategies to strengthen green building zoning requirements to a zero net carbon standard for new construction [as] a critical step for advancing practices to meet the City of Boston's goal for Boston to be carbon neutral by 2050." The BPDA engaged with Boston residents and professions to join discussions and assist in the development of the ZNC Zoning, including the creation of four Technical Advisory Groups (TAGs) organized around the following areas: Low Carbon Building, On-Site Renewable Energy, Renewable Energy Procurement, and Embodied Carbon.

The Renewable Energy Procurement TAG was facilitated by Architecture 2030 and consisted of fourteen Boston-area professionals and fourteen members of the City of Boston staff from various departments. Four meetings were held by the Renewable Energy Procurement TAG focusing on i) the framework and potential pathways for renewable energy procurement, ii) allowable renewable energy procurement options, iii) minimum requirements for the renewable energy procurement options, and iv) social equity in renewable energy procurement.

This report was developed by Architecture 2030 and draws many recommendations from the organization's work on the ZERO Code, now a ICC-approved appendix to the the 2021 IECC - Appendix CC: Zero Energy Commercial Building Provisions. This report considers the knowledge, guidance and expertise provided by the Renewable Energy Procurement TAG in order to craft recommendations that are appropriate to the Boston context and align with related policy development, such as the proposed Building Emissions Performance Standard (BEPS) in the Building Energy Reporting and Disclosure Ordinance (BERDO) update.

Architecture 2030 would like to acknowledge and thank the members of the Renewable Energy Procurement TAG for their support in the development of these recommendations.

Summary of Recommendations for RE Procurement Requirements

Under ZNC Zoning it is recommended that, via the Cooperation Agreement, new buildings be required to maintain participation or have a contract for renewable energy procurement for the building's net electricity consumption (annual building electricity use less annual on-site renewable electricity production) using one or more of the following mechanisms:

1. Direct Ownership / Self-owned, Off-Site Project (system can be installed through a power purchase agreement)
2. Virtual Power Purchase Agreements (vPPAs)[1] (multiple organizations can aggregate their buying power and may be able to negotiate better terms)
3. Unbundled Renewable Energy Certificates / Credits (RECs)[2]
4. Green Retail Tariffs / Green Pricing (100% renewable programs can be offered by any electric service provider in Massachusetts, including community choice aggregators like Boston's Community Choice Electricity program)
5. Utility Renewable Energy Contract / Direct Access to the Wholesale Markets
6. Renewable Energy Investment Fund

All off-site renewable energy procurement must satisfy three minimum requirements: (1) the generator must qualify as a Massachusetts Class I generator as defined by the Massachusetts Department of Energy Resources (DOER)[3], (2) RECs must be retired on behalf of the ZNC building, and (3) the annual purchase commitment must be validated via the Building Energy Reporting and Disclosure Ordinance (BERDO).

---

1 Wind or solar generators located outside the ISO New England service territory are allowed for virual power purchase agreements when the generators are located in regions where the carbon emissions of the electric grid are higher than those of the New England ISO.

2 When the procurement option is unbundled RECs, the Class I generators must be non-emitting; biomass fired generators do not qualify.

3 Class I Generators shall be built on or after January 1, 1998 and meet the requirements of the RPS Class I regulations. These Units can be located anywhere in the ISO New England control area, as well as in the adjacent control areas (northern Maine, New York, Quebec, or the Canadian Maritime Provinces), provided that they transmit their power into New England and meet other import criteria. DOER maintains a list of qualifying generators. See https://www.mass.gov/service-details/lists-of-qualified-generation-units.

Intent of the Renewable Energy Requirement

The purpose of the Boston renewable energy requirements is to avoid the carbon emissions associated with new building energy use. Residential and commercial buildings are responsible for about 39% of carbon emissions in the United States. About 12% results from the direct use of natural gas and other fossil fuels for heating while 28% results from electricity consumption.[4] In New England, each MWh of electricity generation results in 910 lb of carbon dioxide equivalent (CO_2e) emissions and each therm of gas combustion results in 20 lb of CO_2e emissions.[5] Building energy use and carbon emissions are tightly linked.

New buildings place an additional electric load on the grid and the renewable energy requirement requires that renewable energy be installed on-site and/or procured off-site to make up for this additional load. If new renewable energy production matches the additional load from a building, the carbon impact is close to zero. In effect, the renewable energy requirement accelerates progress toward a clean electric grid by requiring or encouraging new renewable energy generating capacity over and above what the electric service providers are already required to do by the State's renewable portfolio standards (RPS).

The amount of renewable energy required depends on the energy efficiency of the building, the more energy efficient the building, the less renewable energy is needed and the lower the cost of complying with the renewable energy requirement. In the Boston zoning districts, all buildings must use the performance approach to achieve compliance with the locally enforced energy efficiency standards and these energy simulations provide an estimate of the annual net electricity use that must be procured. Net electricity is the annual consumption less that generated by on-site PV systems. While less renewable energy procurement is needed when buildings are more energy efficient, all buildings must comply with the minimum energy efficiency standards adopted by Boston and the State of Massachusetts.[6] A building can never be less energy efficient than code minimum. No matter how much renewable energy is installed or procured, the building has to meet the minimum energy efficiency requirements.

The goal of the renewable energy requirement is that additional renewable energy generators be installed to avoid the carbon emissions from conventional power plants that would otherwise occur. The addition of renewable energy capacity is irrefutable when a PV system is installed on the building roof or building site along with construction of the building. However, this is not always the case with off-site procurement of renewable energy. Minimum requirements are established for all off-site procurement options to address the type of off-site renewable energy generator that qualifies, the length and

---

4 These data are based on data from Lawrence Livermore National Laboratory, https://flowcharts.llnl.gov/commodities/carbon. Residential and commercial buildings are responsible for 75% of electricity use in the United States.

5 Carbon dioxide equivalent emissions include both methane and nitrous oxide based on their global warming potential over a 20-year time horizon. Calculations are by the author. These estimates also include the emissions related to extracting, processing/refining the fuel and delivering it to the building or power plant. Methane leaks along the way are a significant portion of these upstream emissions.

6 The stretch code adopted for Boston requires that buildings larger than 100,000 ft² and shopping centers, laboratories and conditioned warehouses larger than 40,000 ft2 use the performance approach and show that the energy efficiency of the building is 10% better than Standard 90.1-2013, using the performance rating method from Appendix G. Residential buildings must be "solar ready" and include a dedicated space on the roof for collectors, pathways for plumbing or electrical lines and reserved space on the electric service.

durability of the purchase contract and to assure that the renewable energy certificates (RECs) are retired on behalf of the building.

Since buildings account for 39% of carbon dioxide emissions in the United States, the renewable energy procurement requirement can have a big impact on carbon emissions by requiring or encouraging new renewable energy generation when new buildings add electric load to the grid. This will avoid the emissions that would otherwise occur from conventional power generation. This is one of the most effective policy options available to local governments that want to move toward zero carbon emissions.

Residual Electricity in New England

Massachusetts is part of ISO New England which also includes Connecticut, Maine, New Hampshire, Rhode Island, and Vermont. ISO New England acts as the balancing authority for the region. 2019 eGRID data from the United States EPA indicates that most of Massachusetts and about half of New England electricity was generated by natural gas with nuclear being a distant second. These data are displayed in Table 1 and Figure 1. The carbon dioxide emissions rate is 1,264 lb/MWh of electricity generated for Massachusetts and 910 lb/MWh for New England.

Table 1 – Residual Electricity in Massachusetts and New England

		Massachusetts	ISO New England
Generation Mix	Coal	0%	0%
	Petroleum	0%	0%
	Natural Gas	72%	49%
	Other Gases	0%	0%
	Nuclear	10%	30%
	Pumped Storage	0%	0%
	Hydro-electric	3%	7%
	Wood	4%	4%
	Waste	4%	4%
	Geo-thermal	0%	0%
	Solar	5%	2%
	Wind	1%	4%
Carbon Dioxide Equivalent[7] (lb/MWh)	Direct Emissions Rate	884	644
	Indirect Emissions Rate	381	265
	Emissions Rate	1,264	910

[7] The CO_2e emission rates are calculated author using procedures documented in ASHRAE Standard 189.1-2020. These vary from the EPA figures for a several reasons: (1) They include all greenhouse gases, not just CO_2. (2) They include upstream emissions related to extraction, processing and delivery of fuels to the power plants, including methane leaks from gas pipes and distribution systems. (3) The data is based on a 20-year time horizon for global warming potential.

Source Energy Conversion Factor (unitless) [8]	2.67	2.66

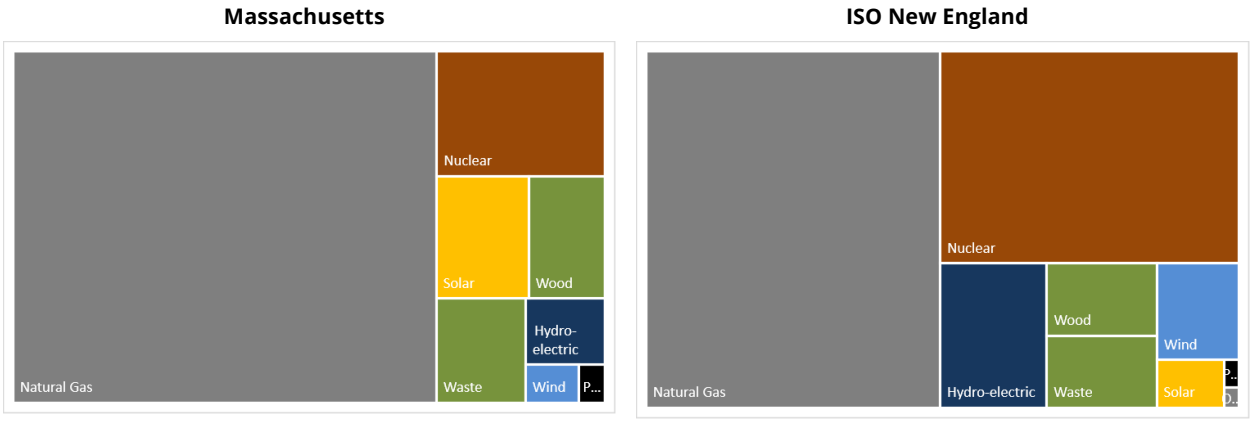


Figure 1 – Mix of Electricity Generation for Massachusetts and ISO New England

Source: 2019 eGRID data

The generation mix in both Massachusetts and New England is becoming cleaner. Figure 2 shows the change for New England that occurred between 2008 and 2017. During this period, coal was practically eliminated as a fuel source for making electricity. Most of the decline in coal was made up with increases in natural gas, although wind grew to 3% of the electricity mix in 2017.

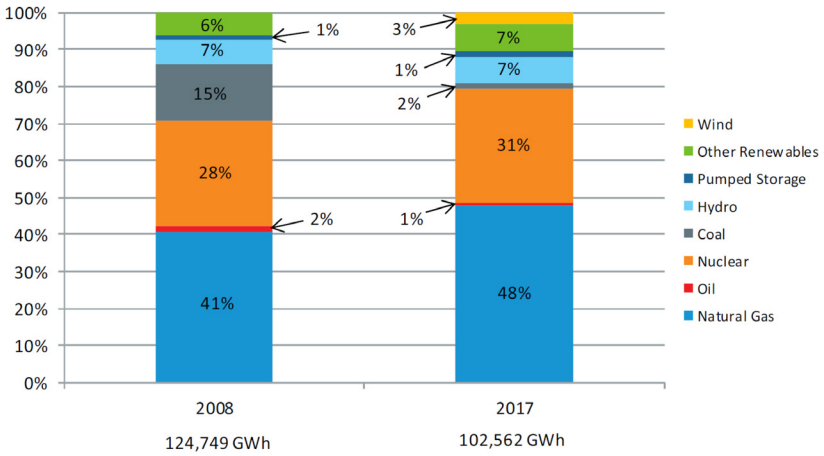


Figure 2 – ISO-NE Percentage energy generation by fuel type, 2008 compared with 2017

Source: 2017 ISO New England Electric Generator Air Emissions Report, ISO New England Inc., System Planning, April 2019, Figure 1-1

The mix of generation fuels is not constant throughout the year. Figure 3 shows the monthly variation in 2017. While oil and coal use are minor on an annual basis, they are still used to some extent during the winter months. Hydro also varies on an annual basis, with peak generation occurring in April and May. In 2017, the data indicate that one or more nuclear facilities were shut down for part of April and the

8 The source energy conversion factor is the ratio of primary energy used to generate electricity to the electric energy delivered to customers. The 2.67 reported value is calculated by the author on ASHRAE Standard 189.1-2020 procedures and assumes that the heat rate for non-combustible renewables is zero.

difference was made up with additional natural gas use. In regions with significant solar on the grid, there are significant hourly variation especially on sunny days that coincide with mild temperatures.[9]

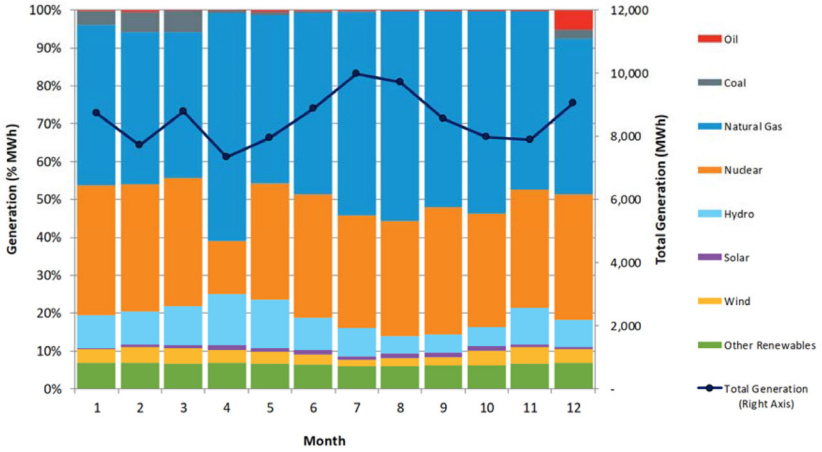


Figure 3 – ISO-NE Monthly Generation by Fuel Type – 2017

Source: 2017 ISO New England Electric Generator Air Emissions Report, ISO New England Inc., System Planning, April 2019, Figure 4-4.

Massachusetts Policies and Programs

Renewable Energy Certificates and NEPOOL-GIS

Generators feed electrons into the New England power grid. Residential, commercial and industrial customers draw electrons from the grid. The generators can be powered by coal, natural gas or oil which results in carbon emissions. Alternatively, the electricity generators can be powered by wind, water, or solar with zero emissions; these are considered non-emitting renewables. Biomass is considered renewable energy in Massachusetts, but it has significant stack emissions at the power plant that must be offset by future carbon capture through photosynthesis. Some of the requirements for renewable energy for ZNC Zoning are limited to non-emitting renewable energy generators.

Once electrons enter the grid, they move according to the laws of physics following the path of least resistance, usually to the closest customer. Electrons generated by coal and solar are indistinguishable; electrons do not arrive with a label saying "I was created by solar". Renewable energy certificates or RECs are used to keep track of the electricity produced by wind, solar and other renewable energy generators. A REC is created for each MWh of electricity generated by renewable energy. RECs can be bundled with the renewable energy (electricity) and sold as a package, or they can be sold separately from the energy (unbundled RECs). There are as many types of RECs as there are renewable energy generators, e.g. wind RECs, solar RECs, hydro RECs, etc. If a customer wants to make a claim that they use 100% renewable energy and they consume 100 MWh of electricity, they must purchase 100 RECs. If they want to be 100%

[9] California is a good example. Net load (that which must be met by dispatchable generators and excluding wind and solar) is very low in the middle of the day when the PV systems are producing and then ramps up steeply in the late afternoon and early evening. This change in hourly demand from year to year forms the infamous "duck curve".

solar, they would purchase 100 solar RECs or sRECs. Once a REC has been used to offset electricity consumption, it is retired. "Retirement means that the REC has been used and can no longer be sold.

If a building owner has solar on their roof but another party owns the RECs, they can't claim that their building is powered by renewable energy. The owner of the RECs has that privilege, even though the solar system may be on someone else's property. This is a common issue with most direct power purchase agreements (PPA). With a direct PPA, a solar system is installed on the customer's roof or parking lot, but it is owned by a third party who often sells the RECs to the electric distribution company to improve the economic viability of the deal. In a case like this, the building owner is helping the electric service provider to meet its RPS requirement, but cannot claim that the building is using renewable energy. The Federal Trade Commission has advised that such a claim would be deceptive.[10]

NEPOOL-GIS keeps track of RECs in New England as well as imported renewable energy from adjacent control areas. It makes sure that RECs are generated by eligible renewable energy generators and are used only once. For each REC, the GIS keeps track of the renewable energy generator that produced it, when the MWh of electricity was generated, who owns the REC, and whether it is active or retired. Other REC tracking organizations work in other parts of the country and provide a similar service.[11] REC tracking systems were first created to manage compliance with mandatory renewable portfolio standards (RPS) requirements, but they are also used to keep track of the sale and purchase of voluntary RECs.

Massachusetts and many other states, require that electric distribution companies provide their customers with a disclosure statement that identifies how the electricity they are selling was generated, e.g. how much came from natural gas, nuclear, solar, wind, etc. The NEPOOL-GIS tracks all generation in New England, not just renewable energy and provides data to electricity providers to enable them to disclose this information to their customers. These disclosure statements are a little like the nutrition labels on food products.

REC Prices

RECs are a financial instrument and like other commodities, the price is a function of available supply and demand. Massachusetts Class I RECs must be produced by Class I generators. See Table 2 and footnotes 3 and 13. This limits the supply. Electric distribution companies must comply with the state RPS requirements by purchasing Class I RECs and a certain amount of these RECs (the solar carveout) must be from Class I solar generators. The RPS requirement creates demand. For these reasons, the price of Massachusetts Class I RECs is significantly higher than non-Class I RECs. Figure 4 shows how the price has changed for the last decade. The price of Massachusetts RECs tracks very closely with those of Rhode Island, New Hampshire and Connecticut. Prices were over $50/MWh and above between 2012 and 2016. Prices are now in the range of $40/MWh after a low in late 2018. The supply of solar RECs is more limited and Massachusetts and other New England bolsters demand by requiring that a

---

[10] The Federal Trade Commision (FTC) Part 260– Guides for the Use of Environmental Marketing Claims, Example 5, page 34.. See https://www.ftc.gov/sites/default/files/attachments/press-releases/ftc-issues-revised-green-guides/greenguides.pdf.

[11] See for instance, Renewable Energy Certificate (REC) Tracking Systems: Costs & Verification Issues, Jenny Heeter, NREL, October 11, 2013, https://www.nrel.gov/docs/fy14osti/60640.pdf.

percentage of the RPS be met by solar, known as the solar carveout. Figure 5 shows prices of solar RECs for the last decade. Since 2015, Class I solar RECs in Massachusetts have been selling between $300 and $400/MWh, many multiples higher than Class I RECs that are not limited to solar.

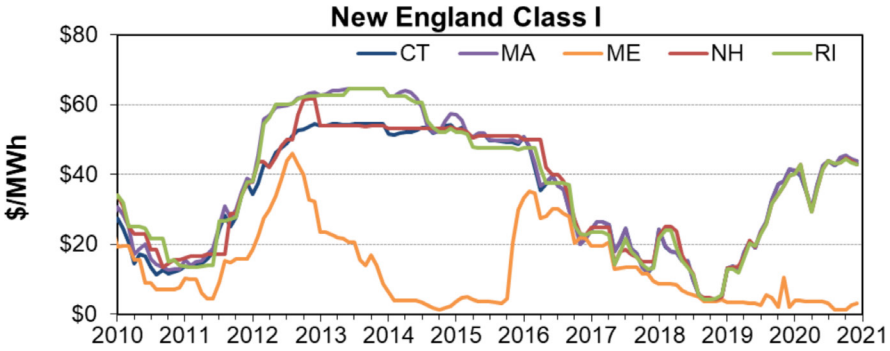


Figure 4 – Price of New England Class I RECs

Source: Galen Barbose, 2021 Annual Status Report, U.S. Renewables Portfolio Standards, February 2021, Berkeley Lab
Class I (Solar) consists of the SREC I, SREC II, and SMART programs; the targets for those programs are denominated in MW and translated here to the equivalent percentage of retail electricity sales.

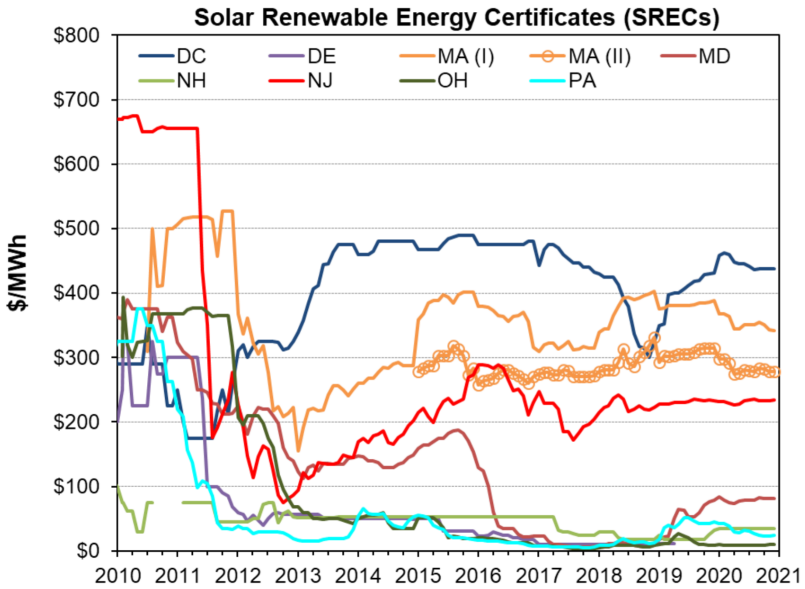


Figure 5 – Price of Solar RECs

Source: Galen Barbose, 2021Annual Status Report, U.S. Renewables Portfolio Standards, February 2021, Berkeley Lab
Class I (Solar) consists of the SREC I, SREC II, and SMART programs; the targets for those programs are denominated in MW and translated here to the equivalent percentage of retail electricity sales.

Many states, including Massachusetts, have alternative compliance payments, which are penalties that electric service companies must pay if they fail to buy enough RECs to meet their mandated RPS targets. Alternative compliance payments set a ceiling price on what eligible RECs would be able to command in compliance markets. In compliance markets, REC prices often hover just below the alternative compliance penalty. See Table 3 for the Massachusetts alternative compliance payments.

When RECs can be produced by any renewable energy generator anywhere in the United States, the price is significantly lower (see Figure 6). In late 2018, prices were around $0.70/MWh, almost 50 times cheaper than Massachusetts Class I RECs. Non-Class I or Class II RECs are commonly used by Massachusetts electricity providers when they offer 100% clean energy (see Table 5). Again, the price of unrestricted national RECs is low because of supply and demand. Wind farms in Texas and the Great Plains are cost effective without the additional revenue from selling RECs. This provides a plentiful supply of non-Class I or non-Class II RECs. More liquidity and supply allow for lower prices relative to current demand.[12]

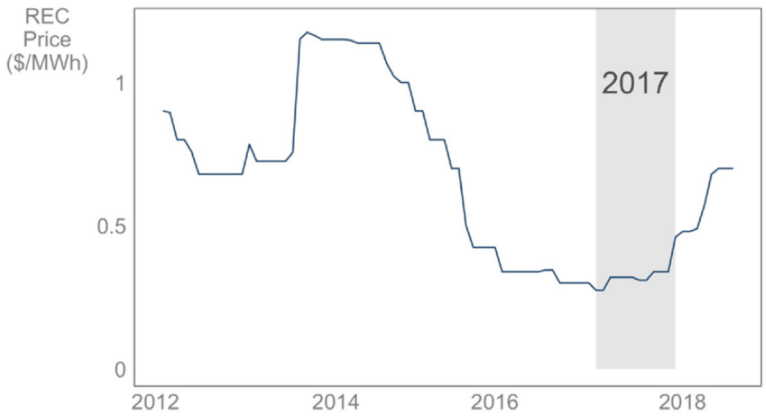


Figure 6 – Voluntary National REC prices, January 2012–August 2018

Source: Status and Trends in the U.S. Voluntary Green Power Market (2017 Data), Eric O'Shaughnessy, et. al. October 2018, NREL/TP-6A-72204

Massachusetts Renewable Portfolio Standards (RPS)

ISO New England serves as the balancing authority for the region and is responsible for assuring that the supply of electricity matches the demand for electricity on a near instantaneous basis. However, the Massachusetts renewable portfolio standards (RPS) require that each electric service provider in the state purchase a minimum amount of renewable energy as a percent of sales. This energy is fed into the ISO New England grid and tracked through renewable energy certificates (RECs). For 2019, the Massachusetts renewable energy portfolio standards (RPS) require that electric distribution companies acquire renewable energy credits (RECs) to represent 14% of their electricity sales. The RECs must qualify as "Massachusetts Class I Compliance RECs"[13], but a carve-out also requires that about 6.2% of electric sales be offset by solar RECs. Table 2 summarizes the number and types of renewable energy generators that qualify for Massachusetts Class I RECs.

---

12 A blog by Katy Kidwell of the Green Energy Consumers Alliance makes a strong case that not all RECs have the same impact. See https://blog.greenenergyconsumers.org/blog/class-i-recs.

13 The requirements for Class I Generators are laid out in the Code of Massachusetts Regulations (225 CMR 14) and specify the type of generator, its location, when it was constructed and other requirements. It is worth noting that renewable energy generators that ISO New England counts as renewable energy may not qualify as Class I generators. In particular, biomass generators must document that the feedstock comes from forest thinnings, forest residues and other specifically defined sources. Also, legacy hydroelectric plants don't count toward the RPS requirements since the intent of the requirements is to encourage the construction of new renewable energy generators. See also Synapse and Sustainable Energy Advantage, An Analysis of the Massachusetts Renewable Portfolio Standard, Prepared for the NECEC in Partnership with Mass Energy, May 2017.

Table 2 – RPS Class I Renewable Energy Generators

Source: RPS Class I Renewable Generation Units, Updated May 5, 2021.

Fuel / Resource / Technology - Type	Qualified (MW)	Qualified & Operational (MW)	Share
Anaerobic Digester - AD	55.425	35.347	1%
Biomass - BM	1.935	1.935	0%
Hydroelectric - HY	67.884	67.704	1%
Hydrokinetic - MH	0.013	0.013	0%
Landfill Gas - LG	258.783	258.783	5%
Photovoltaic - SL, SM, SMAES, SMANG, SMAUN	1,532.250	1,294.850	24%
Tidal - MH	0.900	0.900	0%
Wind - WD	4,385.175	3,759.175	69%
Total	6,302.365	5,418.707	

If an electricity provider is short on renewable energy acquisition at the end of each RPS compliance period, the company makes an Alternative Compliance Payment (ACP) for the difference. The ACP moneys are invested by the Massachusetts Department of Energy Resources (DOER) in a combination of renewable energy and energy efficiency projects. These payments are shown in Table 3 and are around $70/MWh which is significantly more than the cost of non-solar Class I RECs. However, the cost of Class I solar RECs is just below the ACP.

Table 3 – Alternative Compliance Payment (ACP) Amounts ($/MWh)

	2017 Rates	*2018 Rates*	*2021 Rates*
RPS Class I	$67.70	$68.95	$71.57
RPS Class I Solar Carve-Out	$448.00	$426.00	$384.00
RPS Class I Solar Carve-Out II	$350.00	$350.00	$316.00
RPS Class II Renewable Energy	$27.79	$28.30	$29.37
RPS Class II Waste Energy	$11.12	$11.32	$11.75
APS	$22.23	$22.64	$23.50

Source: https://www.nepoolgis.com/2017/02/01/2017-acp-rates-for-massachusetts-rps-and-aps/ and https://www.mass.gov/service-details/annual-compliance-information-for-retail-electric-suppliers

The Massachusetts RPS requirement for various categories of renewable energy is shown in Figure 7 along with the total which will reach about 60% by 2050 if the goals are achieved. Eversource, the distribution company for Boston, acquires RECs through open solicitations.[14] The Massachusetts Department of Public Utilities requires that customers be provided with information on the source of electricity generation through a Disclosure Label.

[14] The following website is a typical RFP for the acquisition of RECs. See https://www.energysage.com/p/eversource/.

Massachusetts also has a Global Warming Solutions Act (GWSA) that works in combination with the RPS requirements. The requirement is for 16% clean electric power in 2018 but increases 2% annually to 80% in 2050. The Act sets a sector-wide, annually declining limit on aggregate CO_2 emissions from 21 large fossil fuel-fired power plants in Massachusetts, from 9.15 million metric tons of CO_2 in 2018 down to 1.8 million metric tons in 2050.[15]

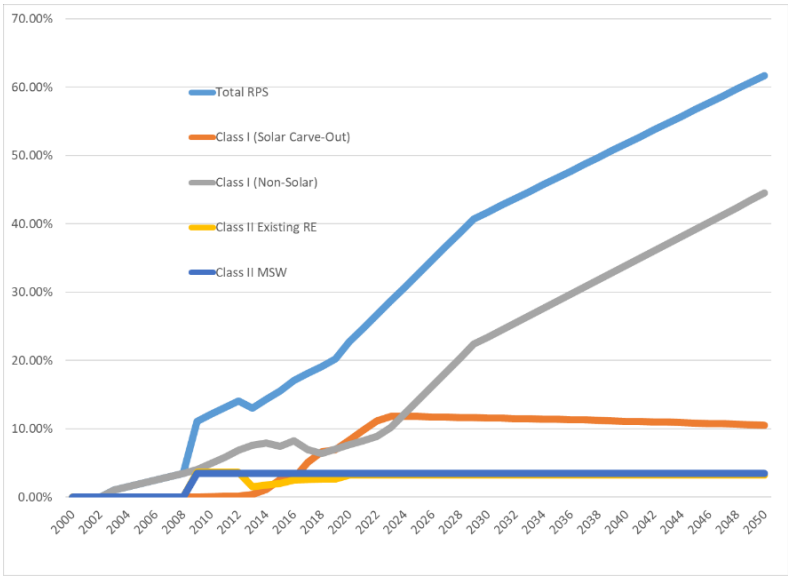


Figure 7 – Massachusetts RPS Percentage Targets

Source: Galen Barbose, 2019 Annual Status Report, U.S. Renewables Portfolio Standards, July 2019, Berkeley Lab
Class I (Solar) consists of the SREC I, SREC II, and SMART programs; the targets for those programs are denominated in MW and translated here to the equivalent percentage of retail electricity sales.

Net Metering

A flexible net-metering program is available for building owners and developers in Massachusetts. With the program, customers are compensated for excess electric power that they generate.[16] However, there are restrictions on renewable energy construction: (1) some areas are not eligible for distributed generating facilities because of interconnection issues,[17] (2) systems must meet minimum requirements set by the distribution company (Eversource),[18] and (3) the total capacity of net-metering accounts is capped at a percentage of the "highest historical peak load, which is the most electricity consumed by

---

15 See https://www.mass.gov/guides/clean-energy-standard-310-cmr-775. See also https://www.mass.gov/files/documents/2018/09/26/3dfs-electricity.pdf for a more detailed explanation.

16 https://www.mass.gov/guides/net-metering-guide is an excellent summary. The Schedule Z is filed with the distribution company (Eversource).

17 Problem areas within the service territory are called the "Area Network", where interconnections are not permitted because of "challenges for interconnection to a solar PV system". The Area Network includes portions of Boston, Cambridge and New Bedford and the neighborhoods of Beacon Hill, Back Bay, Chinatown, Downtown, Fenway area (certain areas), Financial District, North End, South End (certain areas), Theater District, and the West End. See https://www.eversource.com/content/docs/default-source/builders-contractors/boston-area-solar.pdf for more information. There are no maps or detailed descriptions of the "Area Network" for security reasons, but Eversource will provide information to individual property owners when asked.

18 See "Standards for Interconnection of Distributed Generation", https://www.eversource.com/Content/docs/default-source/rates-tariffs/162.pdf?sfvrsn=6. Sometimes there may be a charge for upgrading the grid when this is needed to accommodate a PV system.

the electric company's customers at any one time".[19] However, smaller projects are exempt from the cap. These include single-phase systems less than 10 kW (residential and small building scale) and three-phase systems less than 25 kW. Larger systems must file an Application for a Cap Allocation (ACA) with the System of Assurance of Net Metering Eligibility, which is part of the Massachusetts Department of Public Utilities (DPU). Exported energy for exempt systems is credited at retail rates, however larger systems that need a cap allowance are credited at 60% of the retail rate.

As of December 2019, the NStar (Eversource) net-metering cap is 348,460 kW; 243,273 kW is already interconnected; 24,087 kW has been allocated but not yet interconnected; and 651 kW is pending. The remaining capacity available under the cap is 80,449 kW or about 23%. National Grid, WMECO and Unitil have a waiting list for interconnections.[20] These allocations apply to private systems. Separate allowances apply to public systems and capacity if available except for the areas served by National Grid.

Solar Massachusetts Renewable Target (SMART) Program

The Massachusetts SMART Program is a feed-in tariff program to encourage the construction of solar systems. The program compensates renewable energy developers for energy that they feed into the grid at a rate higher than retail rates. The program is structured in declining tiers. As more solar is installed, the compensation rate declines. However, the RECs do not accrue to the owner or developer of the system. Renewable energy developers must sign an agreement that assigns the RECs to Eversource (in the case of Boston). The SMART program helps Eversource and perhaps other electricity service companies in Massachusetts achieve their RPS requirements, but it does not result in the construction of additional renewable energy over what the RPS program is already requiring. The SMART Program is a way for electric distribution companies to meet their RPS commitment.

Retail Competition

Massachusetts along with 18 other states (see Table 4) has retail competition for electricity. In these states, deregulation has made the electric transmission and distribution systems open to suppliers other than the distribution company. Electricity customers in Massachusetts can choose their own electricity provider, instead of using the default offering of their local distribution company, Eversource in the case of Boston. As of December 2019, 23 companies were offering electricity to retail customers (see Table 5). Many of these companies offer 100% renewable energy. Virtually all of these companies make this offer through the purchase of wind RECs from out of the region, as opposed to Class I RECs that are needed for compliance with the Massachusetts RPS requirements. However, some offerings provide 100% renewable energy from Class I generators, including Boston's Community Choice Electricity Program, which offers 100% renewable energy at a premium of about $0.015/kWh.

[19] See http://www.massaca.org/general-net-metering.asp.

[20] See https://app.massaca.org/allocationreport/report.aspx? for more detail.

Table 4 – States with Electricity Retail Competition

Source: Electric Choice, https://www.electricchoice.com/map-deregulated-energy-markets/

State	*Year*	*State*	*Year*	*State*	*Year*
California[1]	N/A	**Massachusetts**	**1998**	Oregon	1997
Connecticut	1998	Michigan	1998	Pennsylvania	1996
Delaware	1999	New Hampshire	1998	Rhode Island	1996
Illinois	1997	New Jersey	1999	Texas[2]	2002
Maine	2000	New York	1997	Virginia[3]	2007
Maryland	1999	Ohio	1996	Washington DC	2001

Notes:

1 California's electric choice works on a very limited lottery system called DirectAccess.

2 Electricity deregulation is available to 85% of Texans.

3 Electricity choice programs are limited for residential consumers.

Table 5 – Electricity Providers in Eversource Distribution Network

Source: Energy Switch Massachusetts Website, December 10, 2019, Residential Customer Class

	Estimated Monthly Cost (Residential)			
Provider	*100% Renewables*	*Standard Offering*	*Difference*	*Cost ($/kWh)*
Ambit Energy	87.00	81.75	5.25	0.009
CleanChoice Energy	76.80			
Constellation New Energy	77.34	70.74	6.60	0.011
Direct Energy Services	74.64			
Discount Power	77.73			
Eligo Energy MA	84.24	83.04	1.20	0.002
Energy Rewards		71.34		
Green Mountain Energy	82.20			
IGS Energy[1]	76.74	77.34	(0.60)	(0.001)
Indra Energy MA	97.40	96.00	1.40	0.002
Just Energy Massachusetts		74.64		
Liberty Power Holdings	67.73	64.73	3.00	0.005
Massachusetts Gas & Electric		76.74		
NRG Home		85.20		
NSTAR d/b/a Eversource Energy		73.57		
Residents Energy		66.18		
SFE Energy Massachusetts		87.85		
SmartEnergy	83.40			
Starion Energy	66.24	64.44	1.80	0.003
Sunwave Gas & Power		79.08		
Think Energy	75.00			
Town Square Energy	83.82	65.52	18.30	0.031
Verde Energy USA	80.94			
Average from Above	77.80	75.79	4.62	0.008

Notes

1 The 100% renewable rate for IGS Energy requires a 36-month contract term while the standard offering has a 12-month contract term.

2. GreenEnergyConsumers.org is not listed on the Energy Switch website. This organization offers green electricity backed by Massachusetts Class I wind RECs. The cost premium reported on the website is $0.038/kWh ($38/MWh or REC). See http://greenenergyconsumers.org/greenpowered/howswitchingworks#mix.

On-Site Renewable Energy

The most straightforward way to meet the Boston renewable energy requirements is to install solar panels on the roof of the building, over parking lots or elsewhere on the building property[21]. Some large building sites may be able to install wind turbines or incorporate other forms of renewable energy, but solar panels are expected to be the most common form of on-site renewable energy. Large systems must file an Application for a Cap Allowance, but single-phase systems smaller than 10 kW and three-phase systems smaller than 25 kW are exempt. On-site renewable energy systems can be self-owned, or they can be installed through a power purchase agreement, whereby the building owner agrees to purchase electricity from the system for at least 15 years.

The on-site renewable energy requirements of the Boston zoning policy will be recommended via the On-Site Renewable Energy Technical Advisory Group (TAG). The On-Site Renewable Energy TAG will recommend the type of on-site renewable energy qualifies, specifically around how systems installed through the Massachusetts SMART program are considered, given that their RECs do not accrue to the owner or developer of the system. To qualify for ZNC Zoning in general, the RECs must be transferred to the building owner/manager, which is not always the case with direct power purchase agreements.

The net electricity, which is the annual building electricity less the annual on-site PV production, must be provided by 100% renewable energy sources through an acceptable procurement method discussed in the next section.

[21] ASHRAE 189.1-2020 defines an on-site renewable energy system as "renewable energy systems located on any of the following: the building, the property upon which the building is located, a property that shares a boundary with and is under the same ownership or control as the property on which the building is located, or a property that is under the same ownership or control as the property on which the building is located and is separated only by a public right-of-way on which the building is located."

Minimum Requirements for Off-Site Procurement

Boston recognizes several methods for off-site procurement of renewable energy that may be used to supplement on-site systems. The options are listed in the following table along with their applicability in Boston. More detail is provided in Appendix A. See also the ZERO Code technical support document[22].

Table 6 – Boston Off-site Renewable Energy Procurement Options

Procurement Option	*Application to Boston*
Self-Owned Off-site	The Massachusetts net-metering rules support this option. An Eversource customer (host) can allocate excess power generation to other electric accounts (beneficiaries) and the credit shows up on the electric bill of the beneficiary. However, for non-exempt systems, the monetary compensation to utility bills is 60% of the retail rate. However, 100% of the RECs can be assigned.
Community Solar	Limited community solar or community renewable programs are available in Boston, however, the virtual net metering rules allow private systems to be easily set up.
Virtual Power Purchase Agreement	This option is available to large, credit-worthy building owners. The minimum virtual PPA deal is generally 5 MW for solar and 10 MW for wind.
Unbundled RECs	RECs may be purchased by building owners in the open market. Massachusetts Class I Compliance RECs are required for ZNC Zoning.
Green Pricing	Massachusetts has retail competition and many electricity providers offer 100% renewable energy which is commonly achieved through the purchase of non-Class I or non-Class II RECs. See Table 5. The City of Boston's Community Choice Electricity program also offers a green pricing program.
Utility Renewable Energy Contracts	Large customers are able to negotiate with the electric distribution company to supply them with renewable energy through special tariffs or bilateral contracts. No known contracts exist with Boston companies.
Renewable Energy Investment Fund (REIF)	No REIF program exists at the present time, but the City of Boston is considering such a program with a parallel structure to its low-income housing program.

All off-site renewable energy procurement must satisfy three minimum requirements: (1) the generator must qualify as a Massachusetts Class I generator, (2) the purchase commitment must be lasting and verified each year, and (3) RECs must be retired on behalf of the ZNC building. Table 7 lists the common off-site procurement options and shows how each typically complies with the minimum requirements. More detail on these requirements and the exceptions are described below.

[22] ZERO Code Off-Site Procurement of Renewable Energy, Technical Support Document, April 2018. The document can be downloaded from www.zero-code.org.

Table 7 – Minimum Requirements for Off-Site Procurement Methods

	Minimum Requirements		
Procurement Option	*Generation Source*	*Durability*	*Renewable Energy Certificates*
Self-Owned (viable for Boston and supported by virtual net-metering)	Solar is most common but other forms of renewable energy are possible.	The solar system could be sold separately from the complying building, but another acceptable procurement option would be required for BERDO reporting.	Should not be a problem unless the system is installed through a PPA where the seller keeps the RECs or through the Massachusetts SMART program given that the RECs do not accrue to the owner or developer of the system. Forward contracts can be structured to assure that the RECs are assigned to the complying building over the long term, even if the system is sold separately from the complying building.
Community Solar (no known public programs in Boston)	Usually solar but could be another type of renewable energy generator.	It's easy to opt out of most programs, but verification would be provided through BERDO reporting.	Many community solar programs do not provide RECs to the participant. These programs would not be eligible.
Virtual PPA (limited to large credit-worthy organizations)	Wind and solar are the most common, but other generator types are possible.	Not a problem. The renewable energy developer requires a long-term commitment. The contract is verified through BERDO reporting.	Providing RECs to the buyer is the essence of the deal.
Unbundled RECs (Massachusetts Class I RECs are required with few exceptions)	Generator must be *non-emitting* Massachusetts Class I to qualify.	Forward contracts can be used to establish a long-term commitment. Verification is through BERDO reporting.	RECs are the asset being purchased.
Green Tariffs (includes competitive suppliers and CCAs like the City of Boston's Community Choice Electricity program)	Eligible programs must be backed by Massachusetts Class I generators, but some existing programs are backed by out-of-state wind RECs.	The longest typical contract is 36 months and it's easy to opt out, but verification is required through BERDO reporting.	RECs are required in order for the electricity supplier to offer renewable energy.
Utility Renewable Contracts (no known contracts in Massachusetts)	Wind and solar are most typical.	Contracts are typically long-term, but verification is required through BERDO reporting.	Customers contract for RECs and energy.
Renewable Energy Investment Fund (REIF) (multiple investment options)	REIF management establishes criteria.	Contribution can be an up-front payment or a subscription.	RECs should not be a problem, but there are no precedents.

Renewable Energy Generators

The renewable energy generating source shall be photovoltaic systems, solar thermal power plants, geothermal power plants, wind turbines, or other Class I renewable energy generators as defined and approved by the Massachusetts DOER.[23] However, when the procurement option is unbundled RECs, the Class I generators must be non-emitting; biomass fired generators do not qualify. There is only one exception to the requirement for Massachusetts Class I generators: Wind or solar generators located outside the ISO New England service territory are allowed for virual power purchase agreements when the generators are located in regions where the carbon emissions of the electric grid are higher than those of New England ISO. Table 8 lists the carbon emissions for the New England ISO and each of the eGRID subregions.[24]

[23] See 225 CMR 14.00: Renewable Energy Portfolio Standard – Class I. These regulations allow new run-of-the-river hydro plants and certain biomass electricity generators as long as the fuel is certified to come from forest thinning, forest residues, or other residues. Biomass plants must also have a 60% overall efficiency in order to receive full credit. Elecricity generators currently approved as Class I by DOER are listed in "Eligible Class I Renewable Units 091319.xlsx", dated April 29, 2019.

[24] These data are calculated by the author using information from U.S. EPA's eGRID data for 2019 and using the procedure documented in Informative Appendix J of ASHRAE Standard 189.1-2020.

Table 8 – Electric Grid Carbon Emissions by eGRID Subregion

eGRID Acronym	*eGRID Subregion Name*	*Direct Emissions Rate (lb/MWh)*	*Indirect Emissions Rate (lb/MWh)*	*Emissions Rate (lb/MWh)*
HIOA	HICC Oahu	2,005	458	2,462
MROE	MRO East	1,770	386	2,156
PRMS	Puerto Rico Miscellaneous	1,648	489	2,138
SRMW	SERC Midwest	1,800	337	2,137
HIMS	HICC Miscellaneous	1,511	410	1,921
RFCM	RFC Michigan	1,363	347	1,711
RMPA	WECC Rockies	1,336	310	1,646
AKGD	ASCC Alaska Grid	1,165	411	1,576
NYLI	NPCC Long Island	1,081	464	1,545
RFCW	RFC West	1,225	294	1,519
SRSO	SERC South	1,131	360	1,491
MROW	MRO West	1,233	238	1,471
FRCC	FRCC All	1,001	426	1,426
SPNO	SPP North	1,189	237	1,426
SPSO	SPP South	1,052	328	1,380
SRTV	SERC Tennessee Valley	1,088	271	1,359
AZNM	WECC Southwest	1,017	324	1,340
ERCT	ERCOT All	985	343	1,328
SRMV	SERC Mississippi Valley	949	375	1,324
RFCE	RFC East	798	289	1,087
SRVC	SERC Virginia/Carolina	821	260	1,081
NWPP	WECC Northwest	802	200	1,002
NYCW	NPCC NYC/Westchester	607	305	912
NEWE	**NPCC New England**	**644**	**265**	**910**
AKMS	ASCC Miscellaneous	642	188	831
CAMX	WECC California	577	242	818
NYUP	NPCC Upstate NY	297	133	430

Durability and Enforcement

The building owner shall commit to produring adequate off-site renewable energy for the lifetime of the building. The requirement will be enforced through the City's Building Energy Reporting and Disclosure Ordinance (BERDO). The ordinance requires Boston's large- and medium-sized buildings to report their annual energy and water use. It further requires buildings to complete a major energy savings action or energy assessment every five years.

Projects permitted under zero net-carbon zoning would also have to demonstrate through BERDO that the net electricity comes from 100% renewable sources. Any shortage will be adjusted through an alternative compliance payment. The terms between the City and the development entity would be negotiated in through a Cooperation Agreement which represents a legal contract between the two

parties. The terms of the contract carry over to new owners in the event of property sale. Some of the obligations would be recorded with the property deed.

However the terms of the agreement are expected to be flexible, allowing the building owner to acquire renewable energy through different means over the term of the agreement. If a renewable energy program seizes to exist, the owner can move over to an alternative program without having to renegotiate the Cooperation Agreement with the City. The new or substitute program would just be documented as compliance documents are filed at the end of the BERDO reporting period. Some of the off-site procurement options will require participation for a minimum period of time which will reduce flexibility in some cases. For instance, virtual power purchase agreements typically require the buyer to purchase electricity for a minimum of 15 years.

At the end of each reporting period, the renewable energy procured will be compared to the building's net electricity consumption. If there is a deficit, the building owner will make up the difference through additional RECs purchases or an Alternative Compliance Payment to the City.

Renewable Energy Certificates (RECS)

RECs and other environmental attributes associated with the procured renewable energy shall be assigned to buildings permitted under zero-net-carbon zoning. This requirement prevents double counting of environmental benefits. If the RECs are assigned to another party, they are entitled to claim use of renewable energy, not the building owner. REC ownership is an issue with many community solar programs, some green tariffs and with systems installed through the Massachusetts SMART program.

Renewable Energy Procurement and Equity

The City of Boston's equity framework contains the following goals:

- Institutionalize structures for community decision-making, transparency, leadership, and influence on design of environmental programs and policies.
- Refine environmental policies/programs so that the distribution of individuals and grassroots organizations that participate in and benefit from these programs is equitable and reflective of communities of color, immigrants, refugees, people with low-incomes and limited-English proficiency individuals.

The Renewable Energy Procurement TAG discussed potential equity indicators that could be considered in the development and implementation of the ZNC Zoning requirement for off-site renewable energy. Those included air quality, energy cost burden, workforce development, business/economic development, resilience, access and data collection and transparency.

The Boston Green Ribbon Commission's Carbon Free Boston Report and its associated Social Equity Report 2019 were shared as a reference to the Boston Planning & Development Agency as the report "provides a detailed analysis of the current social equity issues in each of the city's key emissions sectors – buildings, transportation, waste and energy – and identifies how intentional policy design can avoid

unintended consequences and use the City's emissions reduction strategies to address historical social inequities. It ends with a synthesis of equity guidance…" The report includes a section outlining questions and consideration for integrating equity, as well as specific recommendations related to renewable energy (on-site and off-site procurement), including strategies for rooftop solar and municipal aggregation, as well as recommendations for "equitably achieving a carbon-neutral energy supply". The Metropolitan Area Planning Council's Equity Goals and Indicators and Equity Framework were also shared for reference by policymakers.

Finally, the Urban Sustainability Directors Network (USDN) recently published a report entitled Equity and Buildings: A Practice Framework for Local Government Decision Makers. The report includes an overview of "critical issues at the intersection of equity and sustainable buildings" and specific steps for policymakers working in building decarbonization to take to achieve positive equity outcomes.

As stated in the Carbon Free Boston Report "explicitly address[ing] the potential impacts of different policies on social equity and acknowledge[ing] that socially just solutions are as important as technically efficient solutions". It is the recommendation of the Renewable Energy Procurement TAG that the Boston Planning & Development Agency actively engage and collaborate with community-based stakeholders and consider the provided resources in order to inform the renewable energy procurement and implementation requirements for the ZNC Building Zoning Initiative.

Precedents for Requiring 100% Renewable Energy

There are a number of cities and governmental entities that are adopting policies to encourage or require the procurement of off-site renewable energy.

San Francisco, California

In 2019, the City of San Francisco added the Renewable Energy for Commercial Buildings Policy to the city's municipal code. It requires large building to purchase all of their electricity from 100% renewable sources. In San Francisco, building owners have two choices. The investor owned utility, Pacific Gas and Electric, offers 100% solar energy through it's Solar Choice program; and the city's community choice aggregator program, CleanPowerSF, offers 100% wind energy from a nearby wind farm. The program begins in 2022 for commercial buildings larger than 500,000 ft^2. The program applies to buildngs larger than 250,000 ft^2 in 2024 and 50,000 ft^2 in 2030. Compliance with the requirements is enforced through the City's energy benchmarking program (similar to BERDO).

Sydney, Australia

The City of Sydney, Australia is considering requirements for on-site and/or off-site renewable energy in addition to building energy efficiency. Click here. The proposed requirements will apply to new commercial buildings in accordance with Sydney's goal to achieve zero net emissions by 2035. The Australian NABERS and Green Star rating tools will be used to verify building energy efficiency and renewable energy can be provided through a mix of on-site systems and off-site renewable energy purchases. Offsite energy generation plays a key role in Sydney's strategy and can be credited through the purchase and retirement of Large-Scale Generation Certificates (LGCs), purchase of Green Power certificates or through power purchase agreements.

New York, NY

New York's Local Law 97 limits greenhouse gas emissions limits for existing buildings and retrofits larger than 25,000 square feet. The requirements may be met through energy efficiency upgrades, on-site renewable energy or the purchase of off-site renewable energy.

Compliance Examples

Here are some examples on how the program would work.

Example/Scenario One:

1. A new, three-story, all-electric 60,000 ft^2 office building is designed to the latest ASHRAE and IECC codes and is estimated to use 517 MWh of electricity use each year, based on performance simulations used for energy code compliance.

2. The building has a solar PV system on the roof that is estimated to produce 300 MWh each year. The net electricity use is 517 – 300 or 217 MWh/y.

3. The building owner signs up for the Boston Community Choice 100% electricity program. The incremental cost of this program is $38/MWh of electricity purchased. If the building performs as predicted by the energy simulations, the annual cost for the green power would be $8,246 (217 MWh * $38/MWh).

4. The building is managed through a triple-net lease such that the electricity costs, including the premium for 100% electricity are paid for by the tenants. The commitment to 100% renewable electricity is in the terms of the green lease agreement. Each tenant is allocated a share of the on-site PV production, based on the gross floor area they lease.

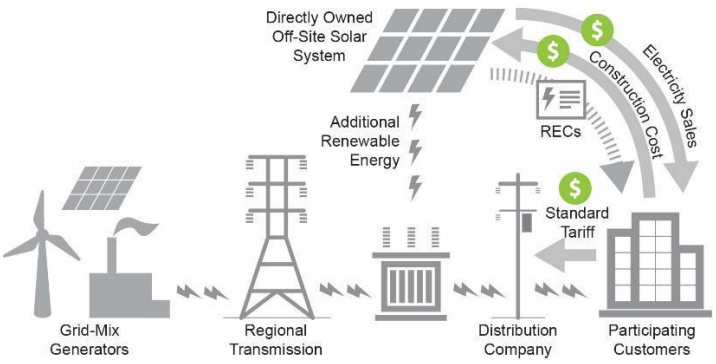
5. In year four, a new tenant moves into the building and takes a whole floor of 30,000 ft^2. They have a lot of energy intensive computers and other equipment and workers arrive early and stay late, both of which increase their building electricity use. The energy simulations estimated that one floor would use 172 MWh/y, but with the special equipment and longer hours, this tenant uses 220 MWh/y.

6. Because of the triple-net lease, the tenant pays for the additional 48 MWh of electricity use using the 100% renewable energy commitment specified in the green lease. However, the tenant's allocation of the on-site PV system does not change. The tenant ends up paying an additional $1,824 for the 100% renewable power.

7. The building owner is required to collect from each of the tenants their energy consumption and renewable energy purchases and report this information to BERDO to demonstrate compliance with the program.

Appendix A – Description of Off-Site Procurement Options and Cost

Self-Owned Off-Site Directly Owned



With self-owned off-site or direct ownership, the complying building developer/owner installs a renewable energy system on a separate parcel of land from the complying building. The complying building would draw power from the grid while the off-site renewable energy system would deliver power to the grid. The Massachusetts virtual net-metering program allows some or all of the electricity and RECs to be assigned to the electricity account of the complying building.[25] Renewable energy production is credited to the electricity account(s) as if the renewable energy system were located on-site. Larger renewable energy systems might serve portfolios of buildings or campuses.

Virtual net-metering may also be used in Massachusetts for on-site renewable energy systems. See footnote 21 for how on-site renewable energy is defined. An example is an apartment or condominium building where each dwelling unit has a separate electricity account. A shopping center with a common renewable energy system serving multiple stores is another example.

In states like Massachusetts with virtual net-metering programs, keeping track of electricity production and assigning it to specific buildings is handled by the local distribution company. The credit shows up on the bill of the beneficiary account as if the renewable energy system were on-site and behind the meter. The cost credit is 100% of the retail rate for exempt systems[26] but 60% of retail rates for large non-exempt systems. While cost is credited at 60% for non-exempt systems, RECs may be credited at 100%. The owner/operator of the renewable energy system files a Schedule Z with the distribution company (Eversource) which names the electric accounts that are to receive a share of the production. The Schedule Z can be filed twice a year.

A forward contract[27] can also be used to assure that electricity and RECs are assigned to the building for a minimum period of time. This addresses the possibility of the off-site renewable energy system being sold separately from the complying building and assures that the RECs are assigned to the complying building for a specified term. Assignment of the RECs would be verified through BERDO reporting.

---

25 The Massachusetts net metering program allows production from an off-site system to be assigned to one or more electricity accounts through the filing of a Schedule Z with the distribution company. California has a much more limited program available only to local governments and school districts which is called the renewable energy self-generation bill credit transfer (RES-BCT).

26 Single-phase systems less than 10 kW and three-phase systems less than 25 kW are exempt.

27 A forward contract is an agreement to buy specified assets at a given price in the future.

Since owning and operating a renewable energy plant is generally not a core competency of most businesses or institutions, many organizations will delegate responsibility for construction and operation to others, especially for large systems.[28]

Cost Considerations

The initial for utility-scale solar PV systems is estimated to be $1,060/kW of installed capacity.[29] The cost estimate for smaller building-scale systems is higher at $1,800/kW of capacity.[30] An investment in solar PV buys the owner both electricity which can be sold into the market or used to reduce the electric bill of a particular building and the environmental benefits or RECs which are needed for projects permitted under ZNC zoning. The electricity that arrives at a building is the same whether it was generated by solar or a conventional fossil fuel generator. The difference is the environmental benefits. The cost differential between solar PV system and a conventional generator is a reasonable estimate of the cost to the building owner of installing solar, either on-site or off-site.

Complying buildings are new construction which add load to the grid. The cost differential can be estimated by comparing the total cost of generating a unit amount of electricity from solar PV, which is the most likely renewable energy system to be used for renewable energy system for self-owned off-site systems, to the total cost of generating the same amount of electricity with a conventional gas generator. The cost difference represents the premium that a building owner would pay and also is a conservative estimate for the value of the associated environmental benefits.

Different types of electric generators can be compared in terms of their levelized cost of electricity (LCOE). LCOE accounts for all costs, including the capital cost or initial cost of building the generator, maintenance and operation costs that occur over the life of the generator, the cost of upgrading the transmission system, annual fuel costs (for fossil fuel generators) and more. These costs which occur in increments over the life of the system are translated into equivalent annualized costs using appropriate fuel prices, fuel escalation rates, discount rate, and system life.

These annualized costs are then divided by the annualized electricity production which accounts for the peak generating capacity and the capacity factor, which is the percent of the time that the generator is expected to operate at full load. The capacity factor for solar is low, on the order of 30%. Wind is 40% to 45%. Combined cycle gas generators are 87% as they are used primarily for baseload while conventional gas combustion turbines are 30% since they are used mostly for reserve and peak loads. The U.S. Energy Information Agency and others have developed procedures for calculating the LCOE of various types of electric generators. The latest data from the EIA are shown in Table 9.

An advanced combined-cycle gas plant (Advanced CC) has the lowest LCOE among conventional dispatchable generators with a cost of $41.2/MWh. More than 75% of the LCOE is fuel. The LCOE of

---

[28] For example, Stanford University contracts with a solar services provider to construct and manage an off-site renewable energy system that offsets power used at the Palo Alto campus.

[29] The cost estimate is for non-tracking (fixed) systems. See https://www.nrel.gov/docs/fy19osti/72399.pdf..

[30] The cost estimate is for non-tracking (fixed) systems. See "Cost and Performance Characteristics of New Generating Technologies, Annual Energy Outlook 2019" (PDF). U.S. Energy Information Administration. 2019. Retrieved 2019-05-10.

solar PV is $60.0/MWh, but this is reduced to $45.70/MWh when tax credits are factored in. Most of the LCOE for solar PV is capital cost with fuel being zero. The incremental cost of solar PV over advanced combined-cycle gas is in the range of $4.5/MWh to $18.8/MWh, depending on whether or not tax credits are considered. Without tax credits, the $18.8/MWh estimate is about half the cost of purchasing Massachusetts Class I RECs which are currently selling for about $40/MWh.

The LCOE data in Table 9 are based on large utility-scale solar PV systems which cost less to build than smaller building-level systems. Based on the initial cost figures cited earlier, the capital cost increase for small systems is in the range of 70%.[31] EIA publishes the range in LCOE, which is presented in Table 10. From Table 10, the maximum LCOE for solar PV is 78% higher than the simple average without tax credits and 74% with tax credits. However, the LCOE maximum for advanced combined-cycle gas is only 17% higher. Working with the maximum LCOE values for solar PV and combined-cycle gas plants from Table 10, the LCOE increment is $58.8/MWh with no tax credits and $31.4/MWh when tax credits are considered. These values are more reasonable for building level systems where the initial construction costs are higher and align more closely to the price of Massachusetts Class I RECs which are about $40/MWh.

In summary, the cost increment for small systems is $58.8/MWh with no tax credits and $31.4/MWh with tax credits. For large systems, the cost increment is $18.8/MWh with no tax credits and $4.5/MWh with tax credits. The LCOE analysis does not factor in the impact of net metering and virtual net metering. These programs compensate building owners at retail rates, or in the case of non-exempt systems 60% of the retail rate.

[31] This is based on $1,800/kW for small systems and $1,060/kW for utility-scale systems.

Table 9 – Simple Average LCOE for New Generation Plants Entering Service in 2023 ($/MWh)

Source: U.S. Energy Information Agency, Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2019, February 2019, Table 1b.

Plant type	*Capacity factor (%)*	*Levelized capital cost*	*Levelized fixed O&M*	*Levelized variable O&M (Fuel)*	*Levelized transmiss ion cost*	*Total system LCOE*	*Levelized tax credit*[1]	*Total LCOE including tax credit*
Dispatchable technologies								
Coal with 30% CCS[2]	85	61.3	9.7	32.2	1.1	104.3	NA	104.3
Coal with 90% CCS[2]	85	50.2	11.2	36.0	1.1	98.6	NA	98.6
Conventional CC	87	9.3	1.5	34.4	1.1	46.3	NA	46.3
Advanced CC	87	7.3	1.4	31.5	1.1	41.2	NA	41.2
Advanced CC with CCS	87	19.4	4.5	42.5	1.1	67.5	NA	67.5
Conventional CT	30	28.7	6.9	50.5	3.2	89.3	NA	89.3
Advanced CT	30	17.6	2.7	54.2	3.2	77.7	NA	77.7
Advanced nuclear	90	53.8	13.1	9.5	1.0	77.5	NA	77.5
Geothermal	90	26.7	12.9	0.0	1.4	41.0	-2.7	38.3
Biomass	83	36.3	15.7	39.0	1.2	92.2	NA	92.2
Non-dispatchable technologies								
Wind, onshore	41	39.8	13.7	0.0	2.5	55.9	-6.1	49.8
Wind, offshore	45	107.7	20.3	0.0	2.3	130.4	-12.9	117.5
Solar PV[3]	29	47.8	8.9	0.0	3.4	60.0	-14.3	45.7
Solar thermal	25	119.6	33.3	0.0	4.2	157.1	-35.9	121.2
Hydroelectric[4]	75	29.9	6.2	1.4	1.6	39.1	NA	39.1

1 The tax credit component is based on targeted federal tax credits such as the PTC or ITC available for some technologies. It reflects tax credits available only for plants entering service in 2023 and the substantial phase out of both the PTC and ITC as scheduled under current law. Technologies not eligible for PTC or ITC are indicated as NA or not available. The results are based on a regional model, and state or local incentives are not included in LCOE calculations. See text box on page 2 for details on how the tax credits are represented in the model.

2 Because the New Source Performance Standard (NSPS) under Section 111(b) of the Clean Air Act requires conventional coal plants to be built with CCS to meet specific CO2 emission standards, EIA modeled two levels of CCS removal: 30%, which meets the NSPS, and 90%, which exceeds the NSPS but may be seen as a build option in some scenarios. The coal plant with 30% CCS is assumed to incur a three-percentage-point increase to its cost of capital to represent the risk associated with higher emissions.

3 Costs are expressed in terms of net AC power available to the grid for the installed capacity.

4 As modeled, EIA assumes that hydroelectric generation has seasonal storage so that it can be dispatched within a season, but overall operation is limited by resources available by site and season.

CCS=carbon capture and sequestration. CC=combined-cycle (natural gas). CT=combustion turbine. PV=photovoltaic.

Table 10 – Range in LCOE for New Generation Plants Entering Service in 2023

Source: U.S. Energy Information Agency, Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2019, February 2019, Table 2.

	Without tax credits				*With tax credits[1]*			
Plant Type	*Minimum*	*Simple Average*	*Capacity-Weighted Average[2]*	*Maximum*	*Minimum*	*Simple Average*	*Capacity-Weighted Average[2]*	*Maximum*
Dispatchable technologies								
Coal with 30% CCS[3]	93.7	104.3	NB	124.7	93.7	104.3	NB	124.7
Coal with 90% CCS[3]	89.0	98.6	NB	109.8	89.0	98.6	NB	109.8
Conventional CC	42.4	46.3	42.8	55.0	42.4	46.3	42.8	55.0
Advanced CC	37.8	41.2	40.2	48.1	37.8	41.2	40.2	48.1
Advanced CC with CCS	55.6	67.5	NB	75.7	55.6	67.5	NB	75.7
Conventional CT	84.1	89.3	NB	100.1	84.1	89.3	NB	100.1
Advanced CT	71.1	77.7	77.5	86.7	71.1	77.7	77.5	86.7
Advanced nuclear	75.1	77.5	NB	81.2	75.1	77.5	NB	81.2
Geothermal	38.2	41.0	39.4	46.5	35.9	38.3	36.9	43.1
Biomass	83.1	92.2	92.1	114.1	83.1	92.2	92.1	114.1
Non-dispatchable technologies								
Wind, onshore	38.9	55.9	42.8	72.9	32.8	49.8	36.6	66.8
Wind, offshore	115.5	130.4	117.9	158.8	104.0	117.5	106.5	142.6
Solar PV[4]	40.3	60.0	48.8	106.9	31.5	45.7	37.6	79.5
Solar thermal	138.2	157.1	NB	178.7	107.3	121.2	NB	138.2
Hydroelectric[5]	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1

1 Levelized cost with tax credits reflects tax credits available for plants entering service in 2023. See note 1 in Tables 1a and 1b.

2 The capacity-weighted average is the average levelized cost per technology, weighted by the new capacity coming online in each region. The capacity additions for each region are based on additions from 2021–2023. Technologies for which capacity additions are not expected do not have a capacity-weighted average and are marked as NB or not built.

3 Because the New Source Performance Standard (NSPS) under Section 111(b) of the Clean Air Act requires conventional coal plants to be built with CCS to meet specific CO2 emission standards, EIA modeled two levels of CCS removal: 30%, which meets the NSPS, and 90%, which exceeds the NSPS but may be seen as a build option in some scenarios. The coal plant with 30% CCS is assumed to incur a three-percentage-point increase to its cost of capital to represent the risk associated with higher emissions.

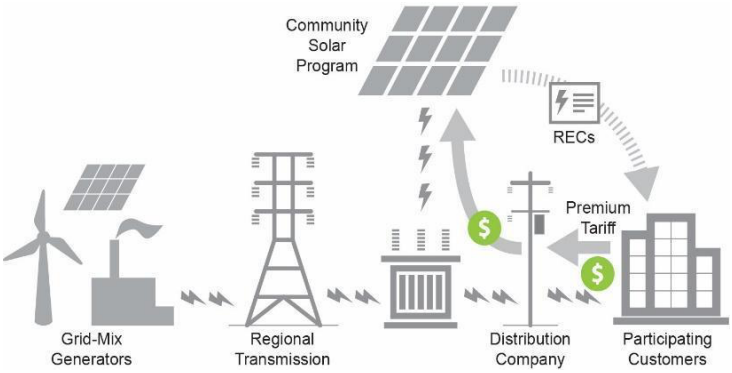
4 Costs are expressed in terms of net AC power available to the grid for the installed capacity.

5 As modeled, EIA assumes that hydroelectric generation has seasonal storage so that it can be dispatched within a season, but overall operation is limited by resources available by site and season.

CCS=carbon capture and sequestration. CC=combined-cycle (natural gas). CT=combustion turbine. PV=photovoltaic.

Note: EIA calculated the levelized costs for non-dispatchable technologies based on the capacity factor for the marginal site modeled in each region, which can vary significantly by region. The capacity factor ranges for these technologies are 37%–46% for onshore wind, 41%–50% for offshore wind, 22%–34% for solar PV, 21%–26% for solar thermal, 76% for hydroelectric. The levelized costs are also affected by regional variations in construction labor rates and capital costs as well as resource availability.

Community Solar



With community solar (or wind), a renewable energy developer constructs a renewable energy system and offers capacity to individual building owners or energy users. It works similar to virtual net-metering in that electricity production is credited to the complying building's electricity account. When available, community solar is an attractive option for small businesses and residential customers that have a moderate load, but can't install on-site renewable energy because of shading or other limitations. The local utility is often a partner with the renewable energy developer, but in Massachusetts, the virtual net-metering rules make this less of a necessity.

There are two participation models for community solar: long-term and short-term. With the long-term model, the building owner/developer purchases or leases enough capacity to offset building energy. The short-term participation model is much more akin to a green pricing program and typically allows the complying building manager to opt out of the agreement on short notice.[32]

While "community solar" or "solar gardens" are the common terms used to describe these programs, most enabling legislation allows other sources of renewable energy, in particular, wind. An advantage of solar is its scalability, in that a portion of the capacity can be easily assigned to each program participant by allocating a number of panels to a particular property. Similar accounting can still be done with wind, but the process is less transparent since most turbines are very large and an individual building would only need a portion of its capacity.

The minimum requirement to assign the RECs and other environmental attributes associated with the renewable energy capacity to the complying building is not satisfied by many community solar systems; most programs keep the RECs and sell them in order to improve the financial viability of the community solar program.[33] Without the RECs, someone else owns the rights to the environmental benefits and participation in such programs does not qualify for buildings permitted through ZNC zoning.

According to the Solar Energy Industries Association (SEIA), 40 states have at least one community solar program on-line, 19 states and D.C. have programs and policies to encourage community solar, and the

---

32 Since solar production is seasonal, most programs require at least a year of participation to include both the cloudy and sunny months.

33 The United States Department of Energy published "A Guide to Community Solar: Utility, Private, and Non-profit Project Development", November 2010. The guide was developed for the National Renewable Energy Lab by Northwest Sustainable Energy for Economic Development, Keyes and Fox, Stoel Rives, and the Bonneville Environmental Foundation. See NREL document 49930. This document provides guidance to organizations what want to set up community solar systems and has examples of programs circa 2010. *Virtually all of the programs cited as examples do not transfer the RECs to the program participants.*

market is expected to increase by 3.5 gigawatts in the next five years.[34] According to EnergySage, the top states are Minnesota with 120 MW of installed capacity, Colorado with 30 MW, and Massachusetts with 70 MW.[35] Some of the community solar programs operating in Massachusetts are listed in Table 11 along with links to their website.

Table 11 – Community Solar Programs in Massachusetts

Source: https://www.solar-estimate.org/news/community-solar-massachusetts

Energy Company	*Community Solar Program*
Clearway Energy Group	Clearway Community Solar (formerly NRG Community Solar)
CleanChoice Energy	CleanChoice Energy Community Solar
Clean Energy Collective	Roofless Solar
CVE North America	Halo Solar
BlueWave Solar	BlueWave Community Solar

Community solar in Massachusetts is made available through the virtual net-metering rules, discussed above. In part because of these rules, there is some confusion as to what constitutes a community solar system. A database developed by NREL, lists 206 community solar programs in Massachusetts with a total capacity of 254 MW.[36] Many of these seem to be private systems that use virtual net metering to assign electricity production and possibly RECs to separate electricity accounts, in many cases condominiums.

As noted earlier, most community solar programs don't quality for ZNC zoning, because the RECs are typically retained by the community solar program or sold to the electric distribution company as a means to comply with state-mandated RPS requirements. Sometimes the RECs are sold separately in the open market. However, there are a few instances when community solar RECs are transferred to the customer. The SolarShare program by Sacramento Municipal Utility District (SMUD) was revised recently so that RECs are provided to the customer. Xcel Energy's Community Solar Garden program in Minnesota allows third party solar project operators to either retire the RECs on behalf of their customers or sell them to the utility for $20 to $30 per MWh.[37]

In Massachusetts, community solar is similar in many ways to self-owned off-site systems. In both cases, a single renewable energy system serves multiple buildings or customers and there is a direct credit to the electricity account. The difference is that self-owned off-site systems are private while community solar systems are open to the public and generally owned by a third party or in some cases the utility.

---

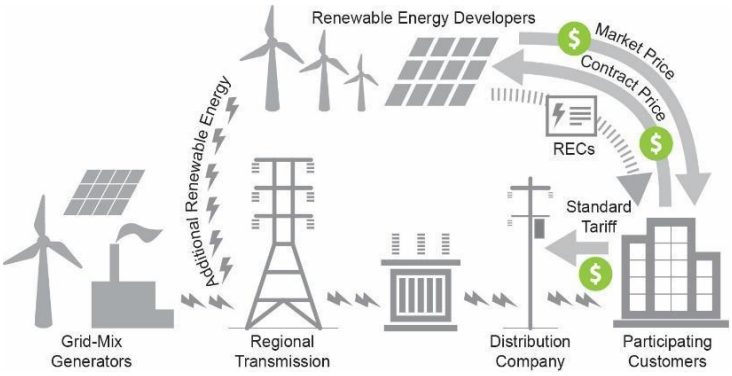
34 See https://seia.org/initiatives/community-solar.

35 See https://news.energysage.com/comparing-top-community-solar-states-minnesota-california-massachusetts-colorado/.

36 A publicly available community solar project list is available at https://data.nrel.gov/submissions/114.

37 The Role of Renewable Energy Certificates in Community Solar, Andrea Romano, January 12, 2016, See https://www.navigantresearch.com/news-and-views/the-role-of-renewable-energy-certificates-in-community-solar.

Virtual Power Purchase Agreements (vPPA)



Direct (or physical) power purchase agreements are a common way to finance and install on-site photovoltaic (PV) systems. Energy service providers install, own and operate the PV system which is located on a building owner's property. The building owner agrees to purchase power from the system for the term of the contract, usually 15 to 20 years according to a schedule of prices agreed to in the contract. The PV developer (or energy service provider) bears the cost and risks associated with construction and operation. The building owner agrees to buy the renewable power for the contract term, but often does not get to claim the environmental benefits since many contracts assign RECs to the seller.

Virtual (or financial) power purchase agreements (PPAs) are a similar arrangement, except that the renewable energy system is not located on the building owner's property. Instead it is located in farm land, pastures, or rural land owned or leased by the renewable energy developer. While direct PPAs are almost exclusively PV systems, virtual PPAs more often are wind. Virtual PPAs are the financial instrument most commonly used by Google, Amazon and other large companies to acquire renewable energy to offset their operations. The buyer (customer) agrees to buy power from the renewable energy developer at a specified price schedule and period of time. In this way, they hedge price fluctuations of the energy market and assume more predictable utility expenses. If prices go up, they benefit; however, if prices go down, they end up paying more. These agreements are often called a "contract of differences".

Unlike direct PPAs, with virtual PPAs, the RECs and environmental benefits are always assigned to the buyer, so they qualify for ZNC zoning. The Rocky Mountain Institute Business Renewables Center developed a Term Sheet for negotiating virtual PPAs and this document makes it clear that the RECs and environmental benefits are assigned to the buyer, in contrast to the typical direct PPA. Since one of the motivations for companies like Google to enter into virtual PPA contracts is to claim the environmental benefits, having the RECs assigned to them is essential.

Scalability is a challenge with virtual PPAs. The minimum size for solar virtual PPAs is about 5 MW and the minimum size for wind PPAs is about 10 MW, but most vPPA deals are much larger.[38] A 5 MWh solar system would power approximately one million ft² of office space. Also, the counterparty to the renewable energy developer (purchaser of the vPPA) must have an excellent credit rating. The minimum renewable energy system sizes and need for credit worthiness make vPPAs an unlikely option for small developers or building owners. However, governmental entities, utilities or allied private parties could serve as the counterparty and sell or allocate shares to individual building owners, a process known as

38 Per Blaine Collinson formerly with Edison Energy (Altenex).

aggregation. In 2018, there were only about 27MWhrtual PPAs negotiated in the United States for a total of 23.5 million MWh. The average size of the deal was about 85,000 MWh.[39]

The scale issue can be addressed through aggregation. Companies or organizations can combine their electricity needs and negotiate together with renewable energy developers to achieve the necessary demand and to obtain better terms. Massachusetts Institute of Technology recently partnered with the Boston Medical Center and the Post Office Square Redevelopment Corporation. This partnership issued a request for proposals and signed a vPPA contract with a 60-MW solar project in North Carolina. In this case, MIT took the lead and more than two thirds of the solar production.[40]

Proximity is a potential issue with virtual PPAs. Sometimes the location of the renewable energy system is located in a separate electric grid thousands of miles from the electric load it is offsetting. Many buyers of virtual PPAs prefer to enter agreements with renewable energy systems located close to their facilities or at least in the same electric grid or market. However, out-of-region vPPAs are allowed for ZNC zoning credit if they are located in states that have electric grid emissions greater than Massachusetts. For example Boston University signed a vPPA contract with a wind developer for a 48.6 MW project in South Dakota. A key consideration for BU was that the avoided carbon emissions for renewable energy in South Dakota are significantly higher than a similar wind farm in Massachusetts, since the carbon emission of the grid in South Dakota is greater than Massachusetts.

Another issue is that virtual PPAs are an agreement between an organization (often a corporation) and a renewable energy developer. They are not associated with a particular building permitted through ZNC zoning. This creates an accounting and record keeping challenge, which can be addressed through BERDO reporting. Transparent documentation is needed to assure that an adequate portion of the environmental benefits from a vPPA contract are assigned to the ZNC building for the given period of time and are not double counted. Tying the PPA to a particular building through the vPPA contract could be a challenge since the renewable energy developer is making a deal with a creditworthy counterparty for the duration of the contract. Renewable energy developers would be leery of a deal where the counterparty could change when the building is sold. This is not an issue with Boston's ZNC zoning requirements, because the new ZNC building owner could simply switch to another renewable energy procurement option and document the change through BERDO reporting.

In traditional (vertically organized) electricity markets where the utility owns generation, transmission and distribution (not applicable in Massachusetts), the utility will sometimes serve as the broker for virtual PPAs between renewable energy developers and their large customers.[41] This option is discussed below under utility renewable energy contracts.

---

39 Status and Trends in the Voluntary Market (2018 data), Jenny Heeter, slides presented in September 2019 at the Renewable Energy Markets Conference in San Diego. NREL Document 74862.pdf.

40 The MIT case study is documented in the *Climate Action Playbook* by Breakthrough Energy, February, 2021.

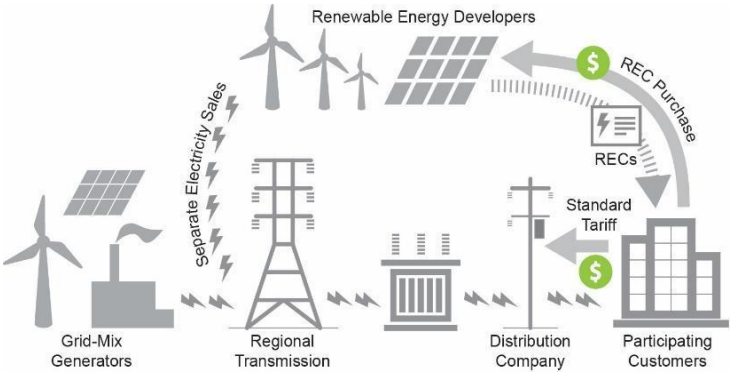
41 See Lori Bird, et. al., Policies for Enabling Corporate Sourcing of Renewable Energy Internationally, A 21st Century Power Partnership Report, NREL/TP-6A50-68149, May 2017

Cost Considerations

The cost of the vPPA to the buyer depends on the terms of the contract and the future sales prices for renewable electricity in the market where the renewable energy system is located. With a virtual PPA, the buyer guarantees the renewable energy developer a minimum wholesale price for the electricity they sell into the market. This is the strike price. If the developer is able to sell at a price higher than the strike, the buyer benefits and receives the difference from the developer. If the developer sells at a price lower than the strike price, the vPPA buyer makes up the difference through a payment to the developer. Because of this feature, vPPAs are often called a "contract of differences". The actual electricity that the buyer receives at the facility is disconnected from the electricity generated by the counterparty in the vPPA, although it is usually the goal of the buyer to match the two.[42]

Cost data is not known for vPPAs, but in this case, program participants would still need to buy their electricity through a competitive supplier or EverSource. It is probably reasonable to assume a cost similar to green pricing programs which are in the range of $33 to $38 per MWh.

Unbundled RECs



Renewable energy certificates (RECs) represent the environmental attributes or benefits associated with renewable energy. With vPPAs and some community solar programs, RECs are used for tracking and verification of the renewable energy purchased, however, RECs can be separated from the underlying renewable energy they are associated with and sold into the open market, typically in increments of one MWh. The concept of RECs is international, but the term used varies in other countries. REC is used in the United States, Australia, India and other places. A variation is called an I-REC (the "I" standing for international). Europe uses the term Guarantees of Origin (GOs), Mexico uses the term Certificados de Energia Limpia (CELs), and the term Tradable Instruments for Global Renewables (TIGRs) is used in other areas. In some countries more than one designation is used.

RECs can be categorized in a number of ways according to the source of renewable energy (type), when the renewable energy was generated (vintage), where it was generated (geography), and when the generator was constructed (age). To approximate the benefit of on-site renewable energy, the source of the renewable energy should be new wind, solar or geothermal generators; production should occur in the same period of time of the building energy that is being offset, and the generator should be new and located in the same geographic area and electric grid of the complying building. As noted earlier, non-emitting Massachusetts Class I RECs are required for ZNC zoning. The market sets a higher price for RECs when more conditions or restrictions apply.

---

[42] This structure causes some organizations, in particular financial institutions, to consider virtual PPAs in the same category as financial derivatives and require that they to be treated as speculative investments.

The purchase of unbundled RECs is perhaps the most flexible method of procuring off-site renewable energy. This option is discussed in the Massachusetts context in the July 11, 2018 report by BR+A Engineers. Unbundled RECs represent the largest share of voluntary renewable energy procurement in the United States. In 2018, 63.2 million RECs were sold representing 47% of all voluntary renewable energy procurement.[43] About 33 million of the 51 million unbundled RECs in 2017 (about two thirds) were generated in just three states: Texas, Oklahoma and Kansas. These were mostly generated by wind turbines

Forward purchase contracts may be structured so that the owner(s) of the ZNC building can buy an adequate number of RECs at a specified price for a minimum period of time, however, such a contract is not required for ZNC zoning, since it is flexible and enforced through BERDO reporting.

Cost Considerations

The price of unbundled RECs depends on whether they are Massachusetts Class I RECs or national unrestricted RECs. The price trend for Class I RECs is shown in Figure 4. This has been as high as $50/MWh between 2013 and 2015. The price dropped to around $5 for a brief time in late 2018, but the price is now about $40/MWh. The five-year running average is in the range of $30/MWh. However, Class I solar RECs are selling for more than eight times general Class I RECs (see Figure 5).

Unrestricted national RECs which are mostly from wind in Texas and the Great Plains are currently selling at about $0.70/MWh. The price was as high as about $1.10/MWh in 2015 and as low as $0.40/MWh in 2016. The five-year running average is about equal to the current price of $0.70. These RECs do not qualify for ZNC zoning compliance.

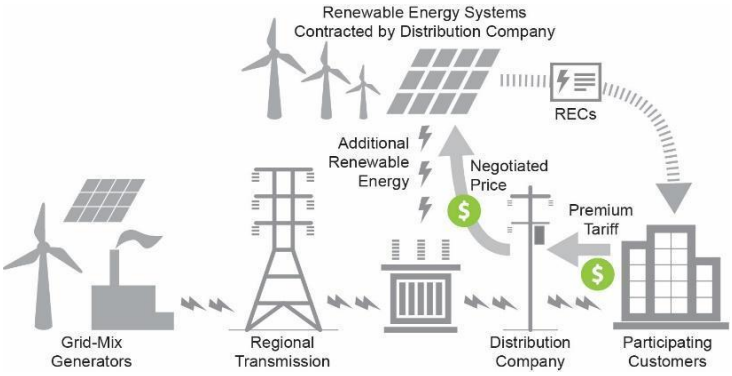
In summary, the current price is about $40/MWh, but the five-year running average is about $30/MWh. Over the last five years, the price has been as high as $50/MWh and as low as $5/MWh. A broker fee or sales commission may result in a slight premium to the prices quoted above.

Green Pricing

Electric distribution companies, community choice aggregators, and competitive electricity suppliers often offer their customers 100% renewable energy from the grid. The Boston Community Choice

---

[43] Status and Trends in the Voluntary Market (2018 data), Jenny Heeter, slides presented in September 2019 at the Renewable Energy Markets Conference in San Diego. NREL Document 74862.pdf.



Electricity program[44] (a CCA) provides an option for 100% renewable energy for its customers. Some of the competitive electricity suppliers also offer 100% renewable energy (see Table 5).

Durability is the principal issue with retail green tariffs. Most of the programs only require a 12-month commitment and 36 months is the longest commitment required by any of the existing programs. Green tariffs are generally voluntary and the customer (buyer) can opt out of the program on short notice and revert back to the standard offering. However, the ZNC zoning requirements will be enforced through BERDO reporting and building owners will be required to demonstrate participation in an acceptable program at the end of each reporting period. The ZNC zoning obligation is passed on to future owners in the event the property is sold.

In other states, some retail providers are addressing the durability issue by allowing customers can pre-pay the premium at the time of building construction.[45] This could possibly enable the premium to be financed from the capital improvement budget. Future building owners and/or tenants would receive 100% renewable energy, but pay according to the standard (default) tariff. Deed notations and/or covenants are other possible means of structuring a long-term commitment.[46] Committing to a single competitive supplier for the long-term may not be attractive to some building owners, but the ZNC zoning obligation is flexible and allows more competitive programs to be substituted in the future.

Being powered by 100% renewable energy will be attractive to tenants in multi-tenant buildings and building owners/developers can pass along the 100% renewable commitment to enable them to claim the use of renewable energy as part of their operations. This arrangement is sometimes referred to as a Green Lease.

Cost Considerations

In Massachusetts, the incremental price for green power depends on whether the electricity is backed by Massachusetts Class I RECs or national unrestricted RECs. The premium for 100% renewable energy from the Boston Community Choice Electricity program is $38/MWh. This is the same as the Green Energy Consumers green tariff which is based on with Massachusetts Class I wind RECs.[47] NREL reports that the typical premium for 100% green power is about $0.033/kWh ($33/MWh) which is in the same range as that reported by Green Energy Consumers.[48] The per-kWh cost for 100% renewable energy

---

44 Green Municipal Aggregation: Community Choice Electricity Program (CCE) https://www.boston.gov/departments/environment/community-choice-electricity and https://communitychoiceboston.org/

45 Sonoma Clean Power, a community choice aggregator serving Sonoma County, is exploring this option as a way to expedite the reconstruction of homes destroyed by the Tubbs fire in Santa Rosa and surrounding areas.

46 The SMUD SolarShares program is technically a community solar program and it provides durability through a deed restriction.

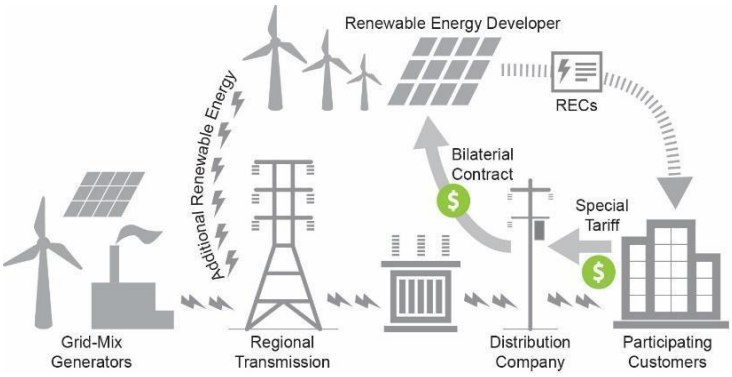
47 See See http://greenenergyconsumers.org/greenpowered/howswitchingworks#mix.

48 Status and Trends in the U.S. Voluntary Green Power Market (2017 Data), Eric O'Shaughnessy, Jenny Heeter, and Jenny Sauer, National Renewable Energy Laboratory, NREL/TP-6A20-72204, October 2018, Figure 9.

through the Boston Community Choice Electricity program is $148/MWh. The rate that complies with the minimum RPS requirements is $110/MWh so the premium is $38/MWh or $0.038/kWh, the same as the program offered by Green Energy Consumers.

As noted earlier, most competitive energy suppliers in Massachusetts currently back their green products with wind RECs from Texas and the Great Plains which do not qualify for credit through the ZNC zoning program. These are far less expensive (see Figure 6); the average premium is about $8/MWh ($0.008/kWh). A reasonable estimate for participating in green pricing programs is $38/MWh.

Utility Renewable Energy Contracts

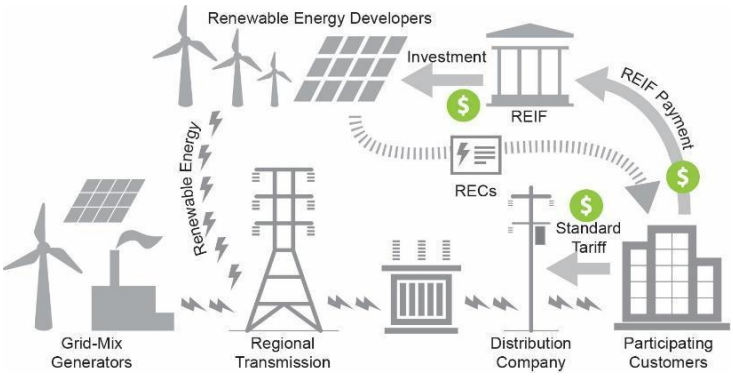


Some utilities offer to procure renewable energy on behalf of large nonresidential customers through a one-off bilateral contract or other arrangement. In these cases, the utility moves the customer to a custom rate structure to reflect the costs of the renewable energy project and retires RECs on behalf of the customer in proportion to their electricity consumption. A key difference between utility renewable energy contracts and retail green tariffs is that customers may negotiate for a particular class of renewable energy generators, e.g. solar. For ZNC zoning qualification, only Massachusetts Class I generators are eligible.

These contracts are sometimes offered as an incentive for large companies to locate a data center or manufacturing plant to the area. In 2017, the NREL database on off-site renewable energy procurement lists just 15 customers for such contracts and the total renewable energy purchased was 2.78 million MWh or an average of 185,000 MWh per customer. NREL reported no utility renewable energy contracts in Massachusetts in 2017. These contracts are geographically concentrated: 60% of total sales were in Iowa with the other 40% scattered between just seven states: Virginia, Nevada, North Carolina, Oklahoma, Nebraska, Georgia and Tennessee.

Renewable Energy Investment Fund

A Renewable Energy Investment Fund (REIF) is a monetary account set up to accept payment from building owners or developers who are unable or don't want to install on-site systems, engage in contracts for renewable energy procurement, or pass along the requirement to participate in renewable energy purchasing to their future tenants (i.e. any of the procurement options listed previously).



Management of the fund can vary, but would likely be a local or provincial governmental entity, although utilities may also have a role, depending on local circumstances.

Low-income housing programs provide a precedent for REIFs. In communities with requirements for low-income housing, developers often have the option to either provide a certain percentage of low-income housing as part of their project or alternatively, they may contribute to a fund and the local housing authority would use to the money to build or contract for low-income housing on another site. Appendix C has examples of low-income housing programs that could provide a precedent for a REIF. Another parallel is the alternative compliance payment that utilities and competitive suppliers pay in the event that they fail to meet their RPS requirements for a certain period (see Table 3). The alternative compliance payment occurs at the end of a BERDO reporting period to true up renewable energy purchases with net electricity consumption, while the REIF payment could be structured as a one-time up-front payment, like contributions to low-income housing programs.

The managing entity for the REIF could use the money in a number of ways, but all of the options should meet the minimum requirements for off-site renewable energy described above:

8. The most direct use of the funds would be to construct or expand a PV system on behalf of the building owner and assign RECs (and perhaps electricity as well through the Massachusetts's virtual net metering program) to the ZNC complying building. In this case, the REIF would own, manage and operate the system(s).[49] Additionality would be achieved and if the system is located in the Boston area, it could provide educational and inspirational value. With this option (and with virtual net metering), the REIF program could function much like a community solar program where participants pay in advance through a REIF contribution for enough capacity to offset the complying building's energy use. System sizes would likely be larger than the 10-kW single-phase or 25 kW three-phase thresholds and the REIF would have to make an Application for a Cap Allowance in order to use virtual net-metering. At present there is about 80 MW of capacity remaining under the cap.

9. Rather than directly owning the renewable energy system, a second alternative is for the REIF to contract with a third-party for the construction, operation and management of the renewable energy system. The third-party renewable energy developer would sell power into the grid through ISO New England, but the environmental attributes associated with the renewable energy, including RECs and/or carbon credits, would be assigned to REIF participants for a

[49] The benefits of the federal investment tax credit would not apply to the city since it pays no federal taxes, but the system could be installed on city property through a direct power purchase agreement. However since many contracts assign the RECs to the seller (renewable energy developer) in direct PPAs, special terms would need to be negotiated.

specific term. They would also transfer to the new property owner in the event of a sale.

The contract with the third-party renewable energy developer could be structured in many ways, but one option would be through a vPPA (see earlier discussion). With this option, the REIF management could set special requirements, e.g. that the renewable energy generator be Massachusetts Class I. Through aggregation, the REIF would enable the vPPA option to work for small customers who may not qualify for a vPPA contract themselves because of the minimum purchase quantity or the need for an excellent credit rating. The REIF would basically serve as an aggregator and distribute the RECs and other benefits of the vPPA to each of the program participants. The REIF would likely need to be backed by the City, since the renewable energy developer would require a counterparty with excellent credit.

10. A third option is for the REIF to purchase unbundled RECs (Massachusetts Class I RECs) on behalf of program participants. Small businesses may find it difficult to locate a broker and directly buy unbundled RECs, and the REIF could make the process seamless for building owners and developers. Again, the program could be structured with a single upfront payment to cover the purchase of RECs for a specific period. REIF management could enter a forward contract to buy the RECs on behalf of all the program participants for the given duration.

If a one-time up-front payment is made to the REIF before building occupancy, the investment might be booked to the capital improvement budget and financed through the mortgage or other long-term financial instruments. The payment would be proportional to the amount of renewable energy needed to achieve compliance with the renewable energy procurement requirement. The renewable energy capacity for each program participant would be determined through energy performance modeling.

If the program is set up properly and effectively managed, it should provide near equivalency to the installation of on-site renewable energy systems in terms of impact and additionality. Contributions to the REIF would result in new renewable energy generation being added to the grid and operated for the long-term. The DOER guidelines for managing alternative compliance payments provide a precedent and the payment itself (see Table 3) could be a reference point for setting the REIF amount.

The REIF concept could also potentially include the funding of local emission reduction projects that benefit environmental justice populations in Boston and support community priorities. This would expand the use of REIF beyond just renewable energy and include projects like energy efficiency for low-income residents, among others. A similar expanded scope is being considered for the use of the Alternative Compliance Payments (ACP) for the proposed Building Emissions Performance Standard (BEPS) in the BERDO update. Additional equity and inclusion focused parameters could also be applied to the fund, such as the oversight of the fund being performed by a review board with community representatives (e.g. 2/3 community representatives is proposed under the BEPS fund referenced above).

Cost Considerations

The amount of money to be paid to the REIF should be adequate to cover the hard and soft costs of building new renewable energy systems (option 1), negotiating and buying a virtual PPA (option 2), or

buying RECs (option 3). If option 1 is managed like a community solar program, then participants would have two benefits: an electricity credit to their utility bill as well the RECs and other renewable energy attributes. In essence, participants would be paying in advance for a given term of electricity (e.g. 15 years) along with the RECs. If the REIF can install a PV system for $1,430/kW[50] and if the system produces 1,425 kWh each year for each kW of capacity[51], the system would produce both electricity and RECs at an annualized cost of $0.092/kWh ($92/MWh) for a 15-year period (or longer).[52] Soft costs would likely increase the cost. These costs include both the electric energy and RECs and do not represent incremental costs.

Compliance Cost Summary

The cost of achieving compliance with each of the procurement methods depends on a number of factors. The cost of some options is fairly straightforward to assess, as the market has set a price, e.g. green pricing and unbundled RECs. The costs of on-site and self-owned off-site systems are a bit more complicated and depend on tax credits and the counterfactual. No data is available for utility contracts or virtual PPAs since these are not common in Massachusetts. Table 12 summarizes the range of costs that can be expected. The assumptions and procedures for developing these costs are discussed earlier.

Table 12 – Cost Comparisons for Procurement Options and Variations for Boston

Procurement Method	*Variation*	*Cost Range ($/MWh)*
On-Site and Self-Owned Off-Site	n.a.	$58.8 small systems with no tax credits, $31.4 small with tax credits $18.8 large systems with no tax credits, $4.5 large systems with tax credits
Community Solar	Up-Front Payment	Not available in Boston but probably similar to green pricing
	Subscription	Not available in Boston but probably similar to green pricing
Virtual PPA	MA Class I Generator	No data available but probably similar to green pricing
	Out of Region	No data available but probably similar to green pricing
Unbundled RECs	MA Class I required	$40 current, $30 five-year running average, $50 high, $5 low
Green Pricing (RECs)	MA Class I required	$33 to $38 based on current offerings and NREL estimates
Utility Contract	Bilateral Agreement	No data available
REIF	Local PV System	See self-owned and on-site systems.
	vPPA Investment	See vPPA
	Unbundled RECs	See unbundled RECs above

[50] This is the average of utility scale systems at $1,040/kW and building scale systems at $1,800/kW.

[51] This is the expected production of a solar PV system in the Boston area with a fixed azimuth and tilt (not tracking).

[52] This is based on a discount rate of 4.2% and a 15-year time horizon. Electricity production after the 15-year period is not considered but has value. However, for simplicity, maintenance and operation costs are not factored in.

Appendix B – Cost Examples for Typical Buildings

There are many different ways for buildings to comply with the renewable energy procurement requirements. Various renewable energy procurement methods and combinations are available. Table 13 gives an estimated of the present value of compliance in dollars per square foot for offices, retail stores, schools, and multi-family residential. These estimates are based on the buildings being designed to the energy efficiency levels specified in ASHRAE Standard 90.1-2019 or the IECC 2021, but it is possible to design buildings that are more energy efficiency. The more energy efficient the building, the lower the compliance cost since less renewable energy needs to be installed or purchased. The estimates represent the premium for renewable energy and do not include the base cost for electricity.

Table 13 – Compliance Costs for Typical Buildings

		Office	Retail	School	Multi-family
		All-Electric Buildings			
Present Value Cost of Compliance ($/ft^2)	Electricity Use (kWh/ft^2-y)	8.62	15.23	11.50	13.79
	Minimum	3.59	6.34	4.79	5.75
	Average	4.25	7.51	5.68	6.80
	Maximum	5.56	9.82	7.42	8.89
		Mixed Fuel Buildlings			
Present Value Cost of Compliance ($/ft^2)	Electricity Use (kWh/ft^2-y)	6.35	9.46	8.49	8.07
	Minimum	2.64	3.94	3.54	3.36
	Average	3.13	4.67	4.19	3.98
	Maximum	4.09	6.10	5.48	5.20

The cost of compliance is a direct function of building electricity use as shown in Figure 8. Larger renewable energy systems are needed with greater electricity use. This provides a significant motivation to design buildings to be more energy efficiency.

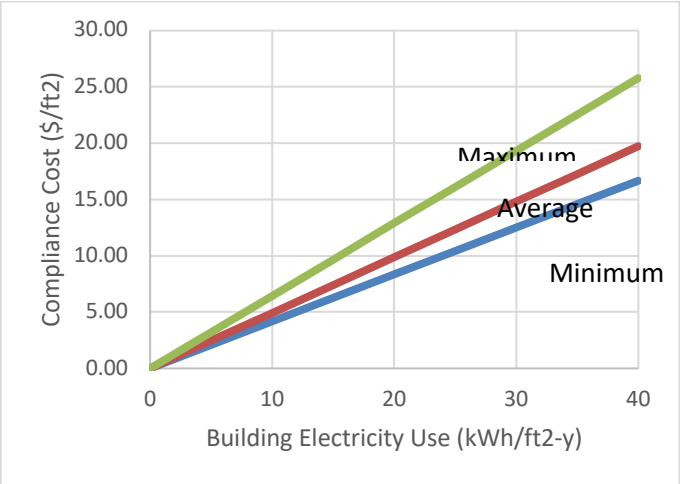


Figure 8 –Compliance Costs vs. Electricity Intensity

Appendix C – Affordable Housing Precedents

Affordable housing programs provide a precedent for the Renewable Energy Investment Fund. The following are examples. Other non-profit and non-governmental precedents also exist for renewable energy investment funds, and these could be further explored as models for developing investment selection and review processes.

Boston's Inclusionary Development Policy Fund

The administration of REIF funds could be modeled after Boston's existing Inclusionary Development Policy Fund, which collects contributions from market-rate housing developments with ten or more units and in need of zoning relief to support the creation of income-restricted housing. Inclusionary Development Policy Funds are used by the City of Boston Department of Neighborhood Development ("DND") to fund the creation of affordable/income restricted housing across Boston. The DND makes funds available to support affordable housing through Requests for Proposals. Proposals that meet the DND's underwriting policies and standards for accessibility, sustainability, good design, and community support are eligible to receive funding from the DND. The DND supports developers who receive funding throughout their projects and can help find eligible tenants for buildings.

Santa Fe's Affordable Housing Trust Fund:

"The Affordable Housing Trust Fund was set up by the City to act as a repository for development fees generated through the affordable housing program, as well as for program income funds that are paid back to the City. Another source of funding is revenue from land sales by the city. To supplement Community Development Block Grant (CDBG) funding, the trust fund was set up so that at least 51% of funds must be used for down payment assistance. Other prioritized activities include rental assistance for very low-income renters and real estate/infrastructure funding to support nonprofit development.

Every year, the City's Community Development Commission sets funding priorities and an Request for Proposals (RFP) is released that is commensurate with the CDBG funding schedule as described in the preceding section. In order to achieve efficiency, the CDC will consider the applications for funding from the Affordable Housing Trust Fund at the same time as CDBG funding requests."

Arlington's Affordable Housing Investment Fund:

Since its creation in 1988, the Affordable Housing Investment Fund has been Arlington County's main financing program for the development of affordable housing. The program has enabled the majority of the approximately 7,500 rental units approved throughout the County to help provide homes for low- and moderate-income households, including specialized housing for the elderly, the homeless, or persons with disabilities.

The Fund supports affordable housing development and preservation in Arlington by:

- Providing low-interest, subordinate loans for developers of affordable housing.
- Subsidizing renovations and upgrades to keep existing affordable housing safe and sustainable.
- Alleviating the dramatic loss of affordable housing units in multifamily properties.

Austin's Affordable Housing Density Bonus Programs

In Austin, affordable housing density bonus programs are neighborhood-specific, and some allow a fee-in-lieu option, wherein developers pay a fee per square foot of bonus area. The funds gathered from

fees may be allocated toward creating affordable housing in the city or investing in the neighborhood of the development: funds gathered through Austin's Downtown Density Bonus feed Permanent Supportive Housing; funds gathered through the North Burnet Gateway density bonus program are invested within two miles of North Burnet Gateway boundaries; funds from the East Riverside Corridor density bonus program are paid into the Transit Area Housing Assistance Fund. Although no examples of a fee-in-lieu option for density bonus programs incentivizing energy efficiency or building electrification have been identified, these could be effectively modeled after the fee-in-lieu option. Using this model, Boston could allow neighborhoods a degree of self-determination in their use of REIF money.

Victoria, British Columbia

Victoria, B.C.'s policy takes a similar but slightly different approach to quantifying the value of increased density and requiring correlated financial contributions: "the City has identified a fixed rate target which will be sought for certain rezoning which result in bonus density. For all other rezoning resulting in bonus density, the City will seek an amenity contribution equivalent to 75% of the additional land value created by the rezoning, based on an economic analysis." This structure could be adapted to require developments that undergo rezoning resulting in bonus density to contribute to a fund supporting energy upgrades in the neighborhood or city.

Appendix D –Template for REIF and Administrative Body

Model Language: The City of Boston shall establish a Renewable Energy Investment Fund (REIF) to act as a repository for fees generated through the Renewable Energy Procurement Requirement and appoint a commission to oversee the administration and impact of the fund. The commission shall include members with expertise in renewable energy, urban development, socioeconomic equity/environmental justice, and investment. The commission shall meet annually to review the impact of current and prior investments, quantify the renewable energy added to the grid through REIF funds, review and revise if necessary the payment requirements, and set funding priorities for the next year.

Boston's Inclusionary Development Policy (see Appendix A) provides a precedent for the authorization, by executive order or inclusion as a zoning article, for:

- Land use policy with long-term impact on ownership and operations
- Terms that are set during the land use permitting and are recorded with the deed to ensure future compliance
- City management of private development mitigation measures

Funds administered as part of a REIF must be managed effectively for long-term additionality and must ultimately contribute significantly to the proportional reduction of greenhouse gas emissions. Key considerations in the structure and administration of a REIF include clarity in purpose, oversight and accountability, and measurement of impact. The administrative authority responsible for the management of REIF funds would:

- Record allotment of funds,

- Quantify the impact from the investments with regard to additional renewable energy systems and reductions in greenhouse gas emissions,
- Periodically review and adjust the investments to ensure that REIF contributions are resulting in new renewable energy generation being added to the grid and operated for the long-term, and
- Verify that RECs are being retired on behalf of the complying buildings that have contributed to the REIF.

Appendix V: TAG Report Public Comments & Responses

Source	Comment Letter
Yve Torrie ABC ytorrie@abettercity.org	**See ABC November 19, 2021,Comment Letter (Page 157)** The submitted questions and comments have been summarized below to allow more direct responses: We are grateful for the City of Boston's continued climateleadership and for your engagement withbusiness leaders through the initiative. We arecommitted to continuing to work with you to find implementable design and constructionstrategies that ensure the next generation of Boston's buildings align with city and statecommitments to achieve net zero emissions by 2050. **A. Proof of Concept in Large Buildings-**Our members have serious concerns about the feasibility of the Carbon Emissions Intensity targets and the requirement of forty percent emissions reductions compared to ASHRAE 90.1-2013. Risk of compromising other industry best practices. Consider other approaches such as electrification. City should share building-specific case studies and associated costs that demonstrate proof of concept in buildings of these types before drafting standards. **B. Consistency with Other Decarbonization Efforts**-Clarify how the ZNC policies fit with other state policies currently underway: opt in Specialized Code for municipalities that DOER is drafting. The Clean Heat Commission setting CAPS (work to be completed by November 2022). The update to the current Stretch Energy Code. **C. Integration into Article 80 Process** -the BPDA should clearly outline the thresholds for the ZNC standard and how any final recommendations will come together into a process that developers will be expected to follow, and what support the BPDA will offer them. **D. Workforce Development**-the City should prioritize workforce development and training opportunities, paying particular attention to providing access to career ladders in underrepresented communities. **Low Carbon Building TAG** • The City should conven a facilitated working session where information can be exchanged between members and BPDA, specific to the feasibility of the recommended targets.Recommend LEED Gold as more appropriate.

Source	Comment Letter
	• Ensuring data reporting requirements include a defined methodology for calculating emissions that allow for the most up-to-date and accurate emissions factors customized to generation sources serving the local grid in Boston. And use the same data reporting requirements to ensure ZNC alignment with BERDO and more accurate localized eGrid factors. • Align ZNC updates with BERDO update timelines of every five years. • The BPDA should establish a ZNC Standard Advisory Group to solicit industry input on the BPDA process for updating the thresholds, targets, and standards in future years. **On-Site Renewable Energy TAG** • We recommend a12-month grace period be extended and/or linked toEversource being at the table and approving projects. We also recommend clarity be provided about how compliance with the on-site renewable energy standard will be incorporated into the certificate of occupancy process. • We further recommend that the BPDA share details on how it plans to manage and staff this new caseload to ensure developers have adequate support in meeting any final requirements. • We recommend the BPDA provide clarity about the conditions under which exemptions can be pursued and what the process for doing so will be. • Clarify if the 50% capacity is for solar infrastructure or solar panels. **Renewable Procurement TAG** • Pursue a Community Choice Aggregation offering a 100% renewable option that has a more reasonable cost premium than the current offering. • Clarify multiple references to a Cooperative Agreement and use. Clarify and make available exemption for wind or solar generators located outside the ISO New England territory through VPPAs located in regions with electric grid emissions higher than New England's ISO. • Clarify what, if any, relationship the Renewable Energy Investment Fund and BERDO's Equitable Emissions Investment Fund will have, and how funding from the Renewable Energy Investment Fund will be allocated.

Source	Comment Letter
	Embodied Carbon TAG • Further engage developers on the feasibility of the TAG recommendations and what intermediate steps are necessary to test proof of concept, increase awareness, and develop markets to support the inclusion of embodied carbon in Boston's ZNC Zoning Initiative

Response

- Thank you for your partnership, the participation and the support of your staff and membership, and your ongoing advocacy efforts for a better Boston!
- The City has already approved numerous new development projects that employ the proposed ZNC framework, meet the proposed pCEI targets, and demonstrate the feasibility of the proposed practices. The proposed pCEI standards are defined as "targets" recognizing unique building conditions and uses could result in a project coming close but not meeting the appropriate target.
- The proposed framework, zoning, and policies anticipate ongoing updates to related codes and building industry standards. With the guidance of the proposed Advisory Board specific aspects of the proposed policies will be updated and revised as warranted.
- On-site emergency power and EV charging loads are not be included in building emissions calculations and proposed CEI targets.
- The recommendations include supporting credentialling of performance modeling professionals and setting corresponding requirements.
- Data reporting, including the Climate Resiliency Checklist, is ongoing and the related calculation methods have been defined and are aligned with BERDO standards including source energy emission factors and predictive Carbon Emission Intensity(pCEI) targets.
- Work force development strategies can include a range of green workforce opportunities. Discussions are ongoing with City and State workforce development offices.

Low Carbon Building TAG

- The BPDA will continue sharing best practices including adding more ZNC projects to the Climate Resilient Building Case Study and is be happy to continue meeting with ABC members.
- The final recommendation is to raise the minimum LEED outcome to LEED Gold.

Response

- Creation of an Article 37 / ZNC Advisory Board is included in the recommendations.
- The proposed ZNC policies are aligned with the new BERDO standards and will be updated to maintain that alignment with any future updates.

On-Site Renewable Energy TAG

- Good idea! A grace period or extension for installation of proposed solar renewable energy systems, defined conditions, and process will be considered.
- The specific recommendations will include area definitions and exceptions for access, safety, shading, and building mechanical systems, among others, that can reduce the solar area in part or entirely.
- The Article 37 review process will be updated to streamline submission requirements, include the proposed ZNC practices, and best align with the Article 80 Review procedures. Additional policies and procedures will be developed to ensure clarity of expectations and consistency in project reviews.

Renewable Energy Procurement TAG

- Currently, the Boston Community Choice Electricity Program's 100% renewable rate is lower than the utility standard rate.
- The BPDA utilizes Cooperation Agreements to record specific project development agreements including building use, design, development, impact mitigation among others.
- The ZNC renewable energy procurement standards are aligned with those in the BERDO and will include future updates. Current and future BERDO regulation setting processes can best consider updates to the VPPA terms and the Renewable Energy Investment Fund concept.

Embodied Carbon TAG

- The proposed ZNC policies include establishing an Advisory Committee to further engage stakeholder and advance related strategies.

Source	Comment Letter
Samira Ahmadi, enviENERGY Studio	• The recommended CEI targets are not consistent with the new published BERDO emissions standards. For example, BERDO sets a target of 1.8 $kgCO_2e/sf/yr$ for a multifamily building during the 2035-2039 period but the ZNC report is recommending 1.6 for high-density multifamily. BERDO's target for an office building is 1.6 by 2040 but the ZNC report recommends 1.6, using the 2035 emissions factors. Are the ZNC recommendations meant to be more stringent than the BERDO targets? I think consistency between the two documents regarding the "Building Typology" and "CEI Targets" would be beneficial. • Molder Accreditation: If feasible, I recommend a minimum of 3-year/ 5-year experience in energy modeling to be added to the list of accreditations. I have been a BEMP accredited for more than 6 years, and I am currently a member of and contributor to the ASHRAE Exam Committee, working on the BEMP Exam Guidelines and I can assure you that having any of these accreditations doesn't make the person a great energy modeler because the exams are mostly based on theories and ASHRAE handbooks and fundamentals. I believe the accreditation requirements should stay but adding a minimum work experience for the modeler or signee would be beneficial.

Response

- The targets are intentionally different. ZNC Building performance targets reflect the potential of new construction building performance and are different from the BERDO targets which reflect the potential for improving older existing buildings.
- We will review Use Type names and definitions for better alignment with BERDO.
- The proposed ZNC policies have been substantially aligned with the new BERDO standards and will be updated to maintain and improve that alignment with any future updates to BERDO.
- The importance of building modeling analysis and the professional accreditation is recognized and will be included in the ZNC Policy and related procedures.

Source	Comment Letter
Lisa Joelle, WSP	Overall, I think the ZNC guidelines are in no way new, they are codifying a lot of the best practices that our WSP projects are currently already taking. We have a number of projects that are already meeting the CEI guidelines, LEED targets and renewable commitments. It is important for these drafts to go into effect to ensure that there is clarity and alignment for all new projects looking to get permitted. I think there are a few items that may benefit from additional investigation/thought leadership from the TAG:

Source	Comment Letter
	1. Alignment of use types names with BERDO, expanding ZNC CEI Targets for space types that exist under BERDO 2.0 CEI Targets 2. Clear path for new construction projects that are close but slightly off from the CEI targets for compliance. Is it just MA Class I REC procurement? Are there other options? 3. Current CEI Targets should evolve over time to address new technologies 4. In order for folks to meet CEI targets I think there should be a larger discussion around incentives for new technologies. For example, we have a number of projects that are studying ASHP DHW and there seem to be no meaningful incentives currently for early adopters of this technology.

Response
• Thank you for your project work and leadership! • We will review Use Type names and definitions for better alignment with BERDO. • We will include expansion of pCEI targets as a near term task for the Advisory Committee. • The pCEI standards are defined as “targets” recognizing unique building conditions could result in projects coming close but not meeting the target. • An Advisory Committee task will be updating performance targets to reflect new technologies, improved performance, and changes in reference standards and codes. • The City / BPDA is working closely with utility and state building efficiency program providers to align current and future incentives to support ZNC practices.

Source	Comment Letter
Scott McBurney & Patrick Haswell, Vicinity Energy	Vicinity Energy strongly disagrees with the carbon equivalent emission factors attributed to district steam identified in the Low Carbon Buildings report / recommendations produced by Thornton Tomasetti (Zero Net Carbon – Low Carbon Buildings, page 12). Table 2. “BERDO-Aligned Carbon Emission Factors'' appears to use the same values presented in a report provided by Synapse Energy Economics to the City of Boston on 2/18/21 which suggests the use of national average

Source	Comment Letter
Scott McBurney & Patrick Haswell, Vicinity Energy	carbon content values from the Energy Star Portfolio Manager (ESPM). Vicinity has previously disputed, in a letter dated 4/6/21, the use of nominal values for all systems in North America as a metric since Vicinity Energy provides to the City of Boston actual Emission Factors for the operation of its Boston district steam system. The value of 66.40 kg CO_2e/MMBtu is overstated for the Boston district system by 139,000 short tons. In 2019, Vicinity provided actual operating data to the City of Boston, per current regulatory requirements, of 25.7 kg CO_2e/MMBtu. Vicinity Energy has provided this data to the City of Boston since 2014. Further, footnote 1, Page 12 of the same report indicates a DOER value of 87.54 kg CO_2e/MMBTU which is believed to be generated from a MEPA response to a recent commercial building development. Vicinity Energy has had multiple, lengthy discussions with the DOER and strongly disagrees with the theoretical carbon attribution methodology the DOER is applying to Vicinity Energy's district steam system. Vicinity Energy is required to report emissions per Federal and MA regulations which are quite clear. Vicinity Energy has a long-term net zero carbon / decarbonization plan for the Boston district system to continue to support the City of Boston and Commonwealth of MA goals to achieve a Net Zero Carbon environment. Vicinity Energy will provide a timeline with forecast CO_2e values by calendar year to support the analysis of Vicinity Energy for development projects for the first year of occupation and calendar year 2035 operation. Vicinity Energy requests that the CO_2e value for district steam be removed from Table 2 and that the footnote regarding the recent DOER theoretical calculation of CO_2e for the Boston district also is removed. The value of 25.7 kg CO_2e/MMBtu in 2019 should be used as a reference in this recommendation report and will be updated by Vicinity Energy on an annual actual basis.

Response

- The City appreciates Vicinity Energy's efforts to decarbonize their distributed steam services.
- The ZNC policies are aligned with Boston's BERDO regulations including the emission factors for local energy sources. The City of Boston is continuing to work with Vicinity Energy in consideration of the referenced emission factors and proposed "eSteam" services.
- The ZNC energy emission factors will follow those in BERDO and will be updated concurrent with future BERDO updates.

Source	Comment Letter
Ben Myers, Boston Properties	Congratulations to you and the team on the progress you're making on net zero zoning in Boston. I support the initiative and have regretfully not had the time to fully participate. For various reasons (empirical, technical, rational) a EUI of 30 kBTU/SF-yr for office is not feasible. I'm very concerned that it is at odds with realistic expectations for healthy, modern workplace energy consumption. We should be driving carbon to zero. We must. We are behind you but cannot support the initiative with this unrealistic energy requirement for office use.

Response

- Thank you for your and Boston Properties support and leadership!
- The City has already approved numerous new development projects that employ the proposed ZNC framework, meet the proposed pCEI targets, and demonstrate practice feasibility.
- The proposed Office Use pCEI standard will be reassessed to ensure it is both feasible and meaningful. The pCEI standard for Office Use is defined as a "target" recognizing unique building conditions and uses could result in a project coming close but not meeting the target.
- The Advisory Committee will be task with updating performance targets, including use specific pCEIs, to ensure targets remain both feasible and meaningful.

Source	Comment Letter
Martine Dion SMMA	1. I support raising the minimum LEED requirement but find Platinum will present site specific challenges in some parts of the city or pending project site existing conditions. I would lean to Gold, as there is a considerable gap between Gold and Platinum (NC and Core Shell). LEED CI Platinum may be more achievable. Maybe with some sort of incentive if they attain LEED Platinum? 2. For existing buildings undergoing substantial renovation, I would recommend a minimum of 15%-20% CEI reduction beyond Code and/ or CEI 12 (2025), 9 (2030) and 7.8 (2035). Maybe a % electric heating / electrification minimum as well? The CEI should be achievable when including some level of upgrades to the enclosure. The current 19.2 at year 2025 and subsequent 17 at 2030 is too high and not supporting the intent of achieving reduction goals.

Response
• Thank you and SMMA for all your excellent project work and your partnership and assistance! • The final recommendation is to raise the minimum LEED outcome to Gold. • Existing building major renovation projects would be expected to target a 40% comparative reduction in GHG emissions. The "target" definition recognizes the unique building conditions of major renovation projects and uses could result in a project coming close but not meeting the target. • The Advisory Committee will be task with updating performance targets and, based on practice experience, could establish major renovation specific performance targets.

Source	Comment Letter
Dan Bailey, Embodied Carbon TAG Member	This turned out really nicely and is quite comprehensive. The introductory sections do a great job framing the issue and explaining the urgency of reducing and eliminating embodied carbon emissions. **Section 1. Include Zero Net Embodied Carbon in the Climate Action Plan Update, paragraph two, sentence two is incomplete:** "Boston's Climate Action Plan (CAP), which has been updated on a regular basis, provides the City with a framework defining and prioritizing City." **Section 2a. Promote Building Reuse:** I'm glad this recommendation appears early in the report – the importance of building reuse is well-explained and the statement of goals is concise, direct, and meaningful. While I'm supportive of the four listed actions, there are opportunities for additional actions to support this goal, particularly related to zoning regulations. The City should consider incentives for building reuse, including waiving parking requirements for adaptive reuse projects and allowing adaptive reuse projects by right even when the existing building is non-conforming. If form-based zoning is pursued, examples of appropriate additions and alterations to existing building types should be included. The City should also go beyond the proposal to "coordinate with and support Article 85 and other city preservation requirements", and should instead work to update and modernize Article 85 (and other preservation regulations) to reflect the fact that existing buildings are not only valuable cultural resources, but also environmental resources. In imposing an Article 85 demolition delay, only the historic and cultural value of a building is currently evaluated. Instead, the Article 85 process should include an

Source	Comment Letter
	explicit evaluation of the environmental impact of demolition as well, and both cultural and environmental value of a building should be considered in determining whether to impose a demolition delay. There's an important aspect of whole building reuse and deconstruction that's missing from section 2 – designing for longevity and reuse. In order to support the goals of section 2 in the future, new buildings must be designed with long life cycles in mind. They should be designed with flexible, and easily adaptable layouts, and easily repairable, salvageable, and/or reusable building materials should be selected. The City should consider additional actions to promote designing new buildings for longevity and reuse. **Section 4:** Will the recommendation for an immediate requirement to provide a whole building LCA with project filings apply to all new construction projects, or only to large, Article 80 projects? Does the City have an assessment of what proportion of Boston's total embodied carbon emissions come from Article 80 projects vs. smaller projects? Perhaps a less rigorous LCA could be required for smaller projects that is less onerous but still provides a meaningful estimate of lifecycle impacts. **Section 11: Workforce Development** The Portland, OR deconstruction ordinance provides another precedent for successful workforce development. Portland worked with the Building Materials and Reuse Association to create a free, city-sponsored workforce training program to create the necessary workforce to support the deconstructions ordinance. Portland's program was aligned with equity goals as well, targeting women, people of color, and others who face barriers to entering the trades. https://www.bloomberg.com/news/articles/2017-06-13/portland-finds-jobs-in-its-ban-on-demolition.

Response

- Thank you for your support and leadership and participation on the Embodied Carbon TAG!
- Excellent points. Current zoning standards for adaptive reuse projects include provisions for parking relief and building non-conformity.
- While Article 85 updates are beyond the scope of this initiative, inclusion of embodied carbon considerations and the inherent environmental value of existing building can be a focus of the next CAP update.
- Great suggestion; project scale can be factored in specific LCA requirements. The initial expectation is building LCAs would be required of large projects and may include more specific focuses.

Response
• Work force development strategies can include a range of green workforce opportunities. Discussions are ongoing with City and State workforce development offices.

Source	Comment Letter
Daniel Whittet, AHA	**General:** Fantastic job, an excellent document and covers a complex subject very well **Introduction:** The Graphic from Arch 2030 showing the role of embodied carbon in total carbon emissions is not very clear. It takes up quite a bit of space and could possibly be reworked. Maybe some kind of Venn or pie diagram comparison ? Total Carbon Now VS Total Carbon as Operational Percent is reduced? **Recommendations** Section 3: I would recommend NOT putting the LEED requirement language in the plan, but just stating the credits to be included. For other Article 37 requirements, actual credit requirements are not stated. They change fairly often as LEED evolves, and the language, while comprehensible to practitioners, is pretty opaque and tedious for a public document. **Other Sections:** Excellent, I think this looks great and congratulate you and everyone who did the hard work of compiling the document.

Response
• Thank you for all your and AHA's excellent work and assistance with the ZNC policies! • We will review the graphic for a better illustration. • Good point; specific LEED credit language will not be included in the Policy.

Source	Comment Letter
Roselin Osser, AKF Architects	Thank you for the opportunity to submit these comments. 1. I recommend clarifying in the document if the 40% below 90.1-2013 is following Appendix G or if for example could be section 11. "Appendix G" is not specifically mentioned anywhere. 2. How does the savings requirement apply to multifamily high rise projects? Some calculations of energy savings relevant to multifamily high rise are not specifically defined by 90.1-2013 Appendix G but

Source	Comment Letter
Roselin Osser, AKF Architects	are covered in other standards such as Energy Star Multifamily High Rise program. This standard includes specific savings calculation methodology for including the benefit Energy Star appliances, low flow domestic hot water fixtures, and in-unit lighting. Would savings in these categories be allowed to be used to achieve the 40%? 3. How does the savings requirement apply to projects utilizing central plants, such as older ones that may not be renovated as part of the scope of work? Specific guidance would be helpful. 4. It is somewhat confusing that the carbon emission intensity target categories do not line up with those covered by BERDO 2.0. I would recommend aligning these if possible. 5. Not strictly about the Boston Zero Net Carbon document, but the BERDO 2.0 document includes the category of "Services" among other building types; however, the category is not defined within the document. I recommend clarifying this somewhere. I just wanted to add that the initiative seems very thorough and we are looking forward to assisting our clients in implementing these significant carbon reduction goals on future projects. As an energy consultant who has worked in the field for 14-15 years, I have done many energy models in assistance of clients who unfortunately only wanted to barely squeak over the (older versions of) energy code or achieve some modest number of LEED points and these new initiatives including BERDO 2.0 are going to make it much easier to achieve more ambitious carbon reduction goals. Another follow up question is that I am looking to learn more about the REC pricing and suppliers in compliance with BERDO 2.0 and Zero Net Carbon Building Zoning Initiative requirements (as per NEPOOL) and am having trouble finding resources on that topic. Can you point me in the right direction?

Response

- We will include references for Appendix G.
- Project predictive performance modeling will be based on common industry practices. As related reference standards are updated, ZNC performance targets will also be updated.
- New buildings connected to existing central energy facilities will calculated GHG emissions based on emission factors for those energy sources per current BERDO regulations and standards.

Response
• We will review Use Type names and definitions, including “Services” for better alignment with BERDO • Please review the BERDO regulation and standards development process for more information on REC pricing.

Source	Comment Letter
Lindsey Lawson, WSP	I am writing in support of the Boston Zero Net Carbon Zoning Code draft language. As a building sustainability professional, I understand that drastic action is needed to prevent the worst effects of climate change and that the built environment plays a big role. The actions proposed in the Zero Net Carbon Zoning Code draft are feasible. I have projects today are going all electric, installing rooftop solar, investigating embodied impacts, and pursuing LEED certification at the highest levels. This is what the Net Zero Carbon Zoning Code seeks to make common practice in Boston and it is achievable. I support maintaining broad based sustainability requirements through the LEED framework and I think that requiring certain credits, such as the Whole Building Life Cycle Assessment and Integrative Process will align development in Boston with the City's climate plan and goals. I would like to see the building use types in BERDO and the Zero Net Carbon Zoning Code draft aligned so that I can more clearly convey to clients what the requirements are for new and existing buildings with the same program. Thank you to the City of Boston and all of the TAG members for creating this draft and pushing forward to a decarbonized future.

Response
• Thank you for your support and project work! • We will continue a comprehensive approach to sustainable building development utilizing the LEED Rating Systems and prioritizing specific credits. • We will review Use Type names and definitions for better alignment with BERDO.

Source	Comment Letter
Mark Handley Director, Government & Community Relations, Harvard	As the City of Boston advances the Zero Net Carbon Building Zoning Initiative, Harvard University’s review of the latest TAG reports has prompted several questions that we hope are clarified as this matter is being deliberated:

Source	Comment Letter
	1. Will there be any consideration for alternative pathways for the requirement of LEED Platinum Certification for LEED v4 NC and LEED for Homes? • In the draft Boston ZNC Low Carbon Building TAG Report, under 2.1 Building Performance Recommendations, there is a recommendation for buildings that are pursuing outstanding performance in low carbon building design could be eligible for regulatory incentives (this includes Living Building Certification). Is this in addition to the requirement for meeting LEED Platinum Certification? 2. We'd like to better understand the recommendation for buildings to be "solar optimized," which includes defining a minimum area for solar in the design process. Have there been any provisions made for building uses like labs that have heavily encumbered roof areas or buildings with limited solar access located in shady locations? • Recommendation is the minimum area be 50% of the building roof that is flat or oriented between 110 and 270 degrees of true north, 90% of the top level if that is open, and 50% of surface parking. • Also mentions to layout roof to maximize space free of obstructions (including minor MEP)

Response
• Thank you for your ongoing partnership and assistance and HU's practice leadership! • The final recommendation is to raise the minimum LEED outcome to Gold. • Solar optimized is intended to ensure on-site renewable energy is considered and prioritized throughout the project planning process. The specific recommendations include area exceptions for access, safety, shading, and building mechanical systems, among others, that can reduce the solar area in part or entirely.

Source	Comment Letter
Rickie Harvey, Boston Clean Energy Coalition	I am writing on behalf of the Boston Clean Energy Coalition (BCEC) in support of the ZNC Building Zoning Initiative. BCEC has watched this process unfold since the start and feels strongly that ZNC zoning is the best way to urgently and strongly rein in building emissions in new buildings, complementing and aligning with the BERDO update to reducing emissions in existing

Source	Comment Letter
	buildings and use types delineated therein. Without taking action on new buildings immediately there is no hope of meeting the city's carbon-neutral goals. BCEC has been impressed by the breadth of expertise tapped by the BPDA in its TAGs and the excellent work done by the engineers, architects, and other outstanding building consultants in the months since this initiative was launched. We must not squander this huge effort by so many and the time spent in determining how best to move forward with ZNC zoning. In addition, the fact that embodied carbon is also being addressed along with maintaining important sustainability requirements makes this initiative invaluable. BCEC has appreciated being able to watch this initiative develop and unfold and looks forward to anything we can do to expedite implementation and support ZNC zoning in the coming months. The time is now for Boston to lead and take bold action; establishing a ZNC standard as laid out in this initiative would make Boston a true leader in the fight against climate. **ON BEHALF OF:MEMBER ORGANIZATIONS** • 350 Mass—Boston Node • Back Bay Green • Boston Climate Action Network • Clean Water Action • Community Action Works (formerly Toxics Action Center) • Dorchester Climate Justice • Environment Massachusetts • Home Energy Efficiency Team (HEET) • Massachusetts Climate Action Network • Mothers Out Front, Boston • Resist the Pipeline • Sierra Club of Massachusetts • West Roxbury Saves Energy

Source	Comment Letter
	ALLY ORGANIZATIONS • Alternatives for Community and Environment (ACE) • Built Environment Plus (formerly USGBC-MA) • Charles River Watershed Association • Gas Leaks Allies (Boston) • Greater Boston Physicians for Social Responsibility • Massachusetts Environmental Justice Alliance • Massachusetts Power Forward • The Metropolitan Area Planning Council • Passive House Massachusetts

Response
• Thank you for your participation, support, and ongoing advocacy! • Agreed; urgent action is needed to reduce carbon emissions from the built environment. • The proposed ZNC policies are envisioned as complimentary to and aligned with the new BERDO standards and will be updated to maintain that alignment with any future updates to BERDO.

Source	Comment Letter
Loie Hayes	1. Now that BERDO has been revised and expanded, it would be a great disservice to developers and property owners if ZNC were not aligned with those BERDO standards. 2. ZNC must account for embodied carbon, otherwise Boston is simply foisting its carbon footprint onto other territories and making a mockery of its assertions to be acting faithfully in the face of the climate emergency.

Source	Comment Letter
Loie Hayes	3. Off-site Renewable Energy accounted for under ZNC must be held to the highest standards to avoid green-washing. 4. Thanks for all your efforts to make ZNC zoning as ambitious and rigorous as possible.

Response

- The proposed ZNC policies are envisioned as complimentary to and aligned with the new BERDO standards and will be updated to maintain that alignment with any future updates to BERDO.
- The proposed ZNC policies recognize the importance of reducing embodied carbon and include establishing an Advisory Committee to advance related strategies and policies.
- Agreed! The off-site renewable energy standards include meaningful requirements and will be closely aligned with BERDO.

Source	Comment Letter
Virginia Leary, WSP	I am writing in support of the Zero Net Carbon Zoning Code Draft language. As a building sustainability professional, I know that building construction and operation creates a significant amount of carbon emissions and therefore is a critical sector to target in climate action plans. Based on my experience in this industry, the measures proposed in the Zero Net Carbon Zoning Code draft are achievable and of the utmost importance. I regularly work on projects that go all electric, investigate embodied impacts, install rooftop solar, and achieve the highest levels of LEED certification. This code will help move the needle and help make Boston a leading city in climate action. A recently BPDA approved project I worked on was able to incorporate numerous elements of this code to achieve the recommended 2035 CEI targets. The ability to make these changes will have last effects on the city as we move towards our net zero goals.

Response

Thank you for your support and your excellent project work!

Source	Comment Letter
Heather Takle, Power Options	For comments, we submit the below questions and request for answers to them as well as a request for accommodations for the challenges highlighted in the questions. 1. Can you please show a decision path flow chart on how a building owner would go through the pathways for compliance? It would be helpful to clearly outline, what an Owner can do if they aren't able to design a building to meet CEI target, what happens next, etc.? Do they move first to onsite renewable generation? And if that still not option, then they move to offsite procurement? 2. Can you provide real examples of buildings in the sectors that have benchmarks and how they comply? What if there are buildings that don't neatly fit one segment? Can modifications be made to benchmark to reflect actual building usage? 3. What if the actual grid mix is lower than assumed for the CEI? Will the CEI be adjusted based on the actual grid energy mix at the time of building permitting application?

Response

- The ZNC framework prioritizes first) low carbon buildings, second) on-site renewable energy, and third) renewable energy procurement.
- The pCEI standards are defined as “targets” recognizing unique building conditions and uses could result in a project coming close but not meeting the appropriate target.
- The City’s Climate Resilient Building Case Study Includes recent development projects meeting, and in several cases exceeding, the proposed bench marks.
- For mixed use occupancies, building performance targets will be a weighted average.
- Project performance analysis will be based on City established emission factors that will be aligned with BERDO standards and updated as necessary.
- The proposed Advisory Committee will be tasked with updating performance targets, including use specific pCEIs, to ensure targets remain both feasible and meaningful.

Source	Comment Letter
Chris Schaffner, The Green Engineer	I heartily support these proposed changes. It is important to raise the bar on overall sustainability as well as carbon, so I strongly support maintaining and increasing the minimum LEED Certification Requirements. You need to address what happens to a building once it is operational. If a building does not operate at the CEI that was modeled, what happens? Does the building have to offset the modeled carbon emissions or the actual carbon emissions? Perhaps BERDO should be amended to require all building permitted after the date the zoning goes into effect to meet the 2050 BERDO emission requirements. Overall this is great work. The City and BPDA is to be commended for taking a leadership position on climate and sustainability. The urgency of our situation demands nothing less.

Response

- Thank you for your support and leadership and the excellent work of The Green Engineer team!
- The proposed ZNC zoning is intended to limit the actual carbon emissions from building operations to an annual net of zero kg CO^2e.
- The adopted BERDO includes provisions for buildings permitted under more restrictive zoning standards including compliance with zero net carbon emission limits.

Source	Comment Letter
George Henderson	Dear Members of the Zero Net Carbon Building Zoning Initiative team: The work you have done is commendable and critical in this time of climate emergency. I support updating Articles 80 and 37 to ensure new buildings are designed and constructed to a net zero carbon standard and are aligned with the new BERDO standards. It is far more efficient and cost-effective to design and build new buildings to a NZC standard at the outset rather than postpone the necessary compliance and pass the associated costs of retrofits on to future owners and tenants. I support the requirement of LEED Platinum in the NZC standard. It is also important to account for embodied carbon in setting the NZC standard, given the significance of this carbon source in the total life cycle of the building. Also, off-site renewable energy should be held to a high standard. Thank you for your efforts.

Response

- Thank you for your support!
- The proposed ZNC policies recognize the importance of reducing embodied carbon and include establishing an Advisory Committee to advance related strategies and policies.
- Agreed! The off-site renewable energy standards include meaningful requirements and will be closely aligned with BERDO.

Source	Comment Letter
Kristen Patneaude Power Options	1. We are concerned that the CEI targets may not be feasible for all buildings within a sector. There are often different building types and uses within the sectors with some much more energy intensive than others. Please clarify in the building code that the CEIs are targets and there will be allowable tolerances for buildings that are unable to meet the target CEIs. 2. We are concerned about the overly broad characterization of the health care sector and defining a single CEI. While the TAG report addresses this issue, it is not clear what evidence there is to use one broad CEI across all of healthcare, applicable from outpatient care or physicians' offices, to large, highly intensive facilities with high acuity patients requiring high airflows, some integrated with high energy intensity research and lab activity. The differences are broad and should be reflected with more segmentations of CEIs across the healthcare sector. 3. Please clarify if in the building code net zero building performance is required on day one of new building occupancy. 4. Please clarify in the building code, related to the Renewable Procurement, what the process is for getting approval for exceptions for unbundled Renewable Energy Certificates purchases outside of ISO-NE service territory. We recommend that any renewable energy procurement for new generation be an allowable compliance pathway, including for new projects outside of ISO-NE. Because VPPAs can be complex in nature, it may be difficult for building owners to satisfy requirements through a VPPA and may prefer to purchase the unbundled RECs only. 5. Please clarify if in the building code all new buildings must include on-site renewable generation if feasible, and provide clear guidelines on the feasibility requirements. 6. Please clarify in the building code how you will account for the discrepancy between the calculated CEI targets (which uses current BERDO carbon emissions factors and predicted 2035 carbon emission factors) and the actual modeled building performance CEI. If the CEI targets use lower overall emissions factors than the actual grid emissions at the time of building design, how will buildings be able to meet these CEI targets?

Response

- The pCEI standards are defined as "targets" recognizing unique building conditions and uses could result in a project coming close but not meeting the appropriate target.
- The Advisory Committee will be task with updating performance targets, including additional use specific pCEIs. and ensuring building carbon emission targets remain both feasible and meaningful.

Response
• Presently, energy and ventilation intensive healthcare facilities are segmented from general use healthcare facilities. The 40% and 30% comparative reduction in GHG emissions targets provide meaningful targets for unique building conditions and uses. • The proposed ZNC zoning limits actual carbon emissions from building operations to an annual net of zero kg CO_2e commencing on day one of occupancy. • The ZNC off-site renewable energy standards are aligned with the related BERDO. Requests for hardship, exceptions, and similar considerations will be addressed per the adopted BERDO and subsequent updates. • The proposed ZNC policies include specific requirements and standards for installation of on-site renewable energy systems for all buildings. • The proposed ZNC zoning limits are for actual carbon emissions from building operations with emission calculations based on the current energy specific emission factors at the time of use.

Source	Comment Letter
John Cleveland / Amy Longsworth, The Boston Green Ribbon Commission	• The ZNC requirement is for zero emissions at the point of occupancy, not "ZNC ready". This is an important distinction that ups the standards. • The compliance and enforcement mechanism will be administered under BERDO 2.0—approved projects then must comply with BERDO 2.0 2050 standards, including ACP payments. I would anticipate that this arrangement would in turn raise the question of how the "hardship" provisions of BERDO would or would not apply to these projects. • I would be prepared for detailed questions about timing – specifically what happens to Article 80 applications that are already in process? Will they be required to reengineer their designs to meet the ZNC requirements, and if so, how will this work? • Focus on harmonizing with BERDO 2.0 is important, so that the zoning is sort of the second half of the pair, is good positioning and provides easy-to-understand context.

Response
• That is correct; ZNC performance is from time of occupancy and onward. • Annual compliance reporting follows BERDO standards which does provide a hardship application. City staff will review the hardship policy and potential application for ZNC projects.

Response
• Projects that have been approved by the Zoning Board of Appeal or the BPDA prior to the Zoning Commission first notice of hearing, would be exempt from the proposed ZNC zoning. All other new projects would be subject to the Zoning update including the ZNC requirements and policies. • The proposed ZNC policies are aligned with the new BERDO standards and will be updated to maintain that alignment with any future updates to BERDO

Source	Comment Letter
Greg Minot, President, Boston Society for Architecture	**See Boston Society for Architecture November 19, 2021 Comment Letter (Page 163)** The submitted questions and comments have been summarized below to allow more direct responses: • The Boston Society for Architecture (BSA) strongly supports the Boston Planning & Development Agency's (BPDA) Net Zero Carbon Building Zoning Initiative. • The work of our members has shown net zero energy buildings are practical, affordable, and possible for essentially every building type. **1. Low Carbon Buildings** • Clarify that there are two compliance pathways: either an absolute carbon emissions intensity (CEI) or a percent reduction from the baseline. • Allow two baseline options: ASHRAE 90.1-2013 Stretch Code Baseline (without additional efficiency measures) or ASHRAE 90.1-2010 LEED Baseline. This will avoid additional energy modeling burden for smaller buildings that will comply with the LEED standard, but are not required to meet the Stretch Code. • Allow flexibility for unique building types and circumstances that are not anticipated by the standard. **2. Renewable Energy** • We applaud the requirement that off-site renewable energy meet additionality standards. **3. Embodied Carbon** • We commend the City of Boston for addressing embodied carbon in this zoning initiative, including requiring buildings to calculate their

Source	Comment Letter
	embodied carbon footprint and creating a technical working group to support and develop further goals around embodied carbon. **4. Broader Sustainability** • We support the recommendation to raise the bar on LEED certification. Sustainability is not the singular topic of carbon emissions, and it must holistically address human and environmental impacts at all scales. We support targeting LEED Platinum, assuming that there will be some flexibility for buildings such as smaller buildings with limited budgets or those on less optimal sites.

Response

- Thank you for your partnership and the leadership, expertise, and work of your membership!
- We will ensure the zoning and policies clearly indicate the two compliance pathways.
- Great point: we will include means for utilizing both baseline options for performance modeling.
- The pCEI standards are defined as "targets" recognizing unique building conditions and uses may warrant flexibility in defining and meeting the appropriate performance target.
- Agreed! The off-site renewable energy standards include additionality along with several other meaningful requirements.
- The importance of reducing embodied carbon is a shared priority and recognized in the ZNC zoning and policies. The proposed Advisory Committee will be tasked with recommending how bes to advance related strategies and policies including calculating embodied carbon footprint.
- The proposed zoning and policies build on the City's holistic approach to sustainability. The final recommendation is to raise the minimum LEED outcome to LEED Gold and certifiable.

Source	Comment Letter
Tom Yardley Vice President, Area Planning and Development, MASCO	**See MASCO November 19, 2021, Comment Letter (Page 168)** The submitted questions and comments have been summarized below to allow more direct responses: **ZNC Policy Framework** • The Alternative Compliance Payment for on-site fossil fuel uses could prove to be very challenging for energy-intense sectors like laboratories and health care. What is the role of the Energy Investment Fund?

Source	Comment Letter
	• Several members are tied to a district energy plant. We would like to better understand the alternatives and ramifications of building a new building under this scenario and how this may affect the CEI accounting. • Do the ZNC standards require an owner to choose all-electric systems and either install renewables, contract for a PPA or buy RECs indefinitely until the grid reaches zero GHGs? • What are the differences of the BERDO carbon emission limits, measured in CEIs, and the ZNC Building emissions targets? Why does the ZNC policy framework include on-site and procured renewable energy options? **Low Carbon Building** • Are there any existing examples of healthcare buildings achieving 7.4 CEI? • It appears that the slide on the Landmark Center III includes 80% of the carbon reduction as coming from the purchase agreement. It would be helpful to clarify how this achieves the low carbon building goals. • There needs to be consistency between what is proposed for both new (ZNC) and existing (BERDO) buildings and use the same reporting platform if possible. • Can BPDA provide clarity on how ZNC regulations for new buildings would align with portfolio reporting for existing buildings under BERDO? In addition, can BPDA provide clarity on whether, once constructed, a new building can become part of a building owner's "existing building" portfolio for BERDO reporting and compliance? • The proposed carbon accounting protocols add a layer of complexity for campus GHG inventories. • Green power contracts, for instance, are typically applied on a campus scale, not to individual buildings. • The GHG emissions factors the BPDA is using, especially for renewable energy procurement, appear to be different than what institutions use. We would be happy to work with BPDA on an approach to reconcile these. • According to the GHG reporting standards, if we procure renewables, we need to use a market-based scope two approach, not location-

Source	Comment Letter
	based (how does the ISO forecast relate to the BERDO factor set). It looks like BPDA is using more of a lifecycle GHG factor (a mix of scope two and scope three). • Portfolio Manager is not set up as a rigorous GHG tracking tool so it would be helpful if the BPDA developed a calculator, or another way to do this. • The MassSave incentives that we rely on to help pay for these projects will likely be using a different set of GHG factors since the state has mandated targets for them based on electricity produced within MA. (https://www.mass.gov/doc/greenhouse-gas-emissions-reduction-goal-for-mass-save/download) • It would be very helpful to see a real-world example of how the BPDA plans to apply this approach to a project from start to finish (i.e., energy model and purchased renewables x GHG factors, compared to current year and 5-year targets). **Renewable Energy Procurement** • How do the criteria for an acceptable VPPA differ from those used by BERDO? It will be very important for the BERDO 2.0 and the new ZNC regulations to interface seamlessly.

Response

- Thank you for the leadership and work of your member organizations for Boston and our residents!
- The potential cost burden associated with Alternative Compliance Payments is noted. Current and future BERDO regulation setting processes can best consider the benefits and details of the Renewable Energy Investment Fund concept.
- New buildings connecting to new or existing distributed energy sources would establish source specific emission factors and calculate building carbon emissions based on usage.
- The ZNC framework prioritizes first) low carbon buildings, second) on-site renewable energy, and third) renewable energy procurement. New buildings should prioritize the use of efficient electric systems to eliminate or minimize any on-site fossil fuel use. To annually achieve ZNC performance, a project would purchase renewable electricity (or environmental attributes) and make Alternative Compliance Payment for any on-site fossil fuel use.
- Both BERDO and the ZNC standards set net carbon emission limits that include the benefits of renewable energy sources. The ZNC standards also include a Building carbon emission target (without renewables) to ensure low carbon building performance is prioritized.

Response
• The MGH Clinical Tower is the only recently proposed licensed healthcare facility and is achieving the ZNC 30% comparative reduction Building Performance target. The pCEI is 9.4 kg CO_2e/sf-yr. • The Landmark Center Lab / Office project has a Building pCEI of 6.17 kg CO_2e/sf-yr, which is equal to a 43.6% reduction in GHG emissions and exceeds the ZNC target. All electricity will be from renewable sources including on-site solar PV. Emissions from on-site natural gas use will be offset by purchasing carbon credits (for future ZNC buildings these would be Alternative Compliance Payments). • ZNC performance compliance is combined with and reported via the BERDO platform. The proposed ZNC policies are aligned with the new BERDO standards and will be updated to maintain that alignment with any future updates to BERDO. • The performance benefits of new ZNC compliant buildings can NOT be combined with a building owner's "existing building" portfolio for BERDO compliance. • The ZNC renewable energy procurement standards will be aligned with those in the BERDO and will include future BERDO updates.

Source	Comment Letter
Tamara Small, CEO, NAIOP Massachusetts / The Commercial Real Estate Development Association	**See NAIOP November 19, 2021, Comment Letter (Page 171)** The submitted questions and comments have been summarized below to allow more direct responses: NAIOP recognizes the importance of achieving Boston's carbon reduction goals and net zero carbon emissions by 2050. NAIOP offers the attached comments and questions with the hope that the Zero Net Carbon Building Zoning Initiative program can be implemented successfully by providing clarity, consistency and predictability throughout the process while being grounded in technical expertise and technological feasibility. **I. General Comments** i. Implementation - Clarify the process for zoning implementation relative to Article 80 Large and Small Project Review; ≥ 50,000 SF and ≥ 20,000 SF. ii. Utility Infrastructure • Consider potential challenges and allow alternatives to achieve carbon reduction goals (e.g. MEP connections and space for air-source heat pumps to replace a boiler system). • Support projects and advocate for utilities to expand capacity to support an all-electric built environment and do not to hold developers accountable if utility capacity is not available.

Source	Comment Letter
	• If infrastructure upgrades are required, those costs should offset other mitigation, or result in density bonuses. • Recognize that building electrification goals require additional transformers from the utility and significant building space. **II. Low Carbon Buildings Technical Advisory Group Report** i. Case Studies - NAIOP is concerned that the building precedents in the Report are not grounded in data gathered in Boston and encourages the BPDA to consider modeling based on Boston-specific assumptions for occupant density and lighting and equipment power density so that building type best practice data informs practical and achievable standards for new projects. ii. Flexibility - NAIOP strongly recommends allowing achieving either the CEI or the percentage reduction targets. iii. Carbon Emissions Intensity (CEI) • The CEI Targets illustrated in Table 1 appear to incorrectly reference the 2035 BERDO Targets. • The CEI target for housing, a carbon per square foot metrics, is easier for larger projects with having less density. Rather, NAIOP proposes a comparative percentage reduction or per occupant standard to encourage both density and efficiency. iv. Baseline - NAIOP recommends that the design teams be allowed to select LEED standards as the Baseline or ASHRAE. v. LEED - LEED Platinum is often impossible to achieve from both a technological and cost standpoint. NAIOP recommends setting a point target rather than a Platinum target, and is happy to discuss to ensure a target that balance flexibility and carbon reduction. **III. Onsite Renewable Energy Technical Advisory Group Report** i. Financial Analysis of Case Study 1 Regarding Labs - NAIOP is concerned that this case study does not adequately demonstrate the total capital installation cost assumption. NAIOP urges the BPDA to revisit this cost assumption and do additional analysis to ensure accuracy. ii. Solar Photovoltaic (PV) Systems - NAIOP hopes the City will consider an immediate benefit to defer the initial cost of the solar system and the BPDA will recommend an immediate property tax credit applicable to the

Source	Comment Letter
	year of installation set at a percentage of the initial capital cost. iii. Solar Optimization and Urban Design - NAIOP is concerned with the statement: "Solar optimization and building and urban design options and priorities are to be equally considered". How does the BPDA plan to manage competing priorities of shadow restrictions, wind considerations, mechanical noise issues and other competing priorities? NAIOP urges the adoption of language that clarifies how such situations will be managed. **IV. Embodied Carbon Technical Advisory Group Report** NAIOP does not believe that there is enough data available to determine from a net-zero viewpoint if it is better to tear down an existing building and build a new one to achieve carbon neutrality. NAIOP urges the adoption of language that recognizes the savings from the reuse of existing buildings, the salvage of materials etc. in calculations of carbon neutrality and compliance with the new zoning Article. **V. Renewable Energy Procurement Technical Advisory Group Report** i. Massachusetts Class 1 RECs Requirement - There is a fundamental divergence between the Ordinance's requirements for existing buildings and what this recommendation would mean for new building design and development. The updated BERDO requires purchasing of incremental amounts of power over time. Zero net carbon buildings must offset all of their power with renewable energy certificates. Massachusetts Class 1 RECs cost eight to ten times more than green e-certified non-geographically constrained RECs and requiring all new buildings in the City to buy them will cause an additional price spike. This recommendation, if adopted, will result in significant additional costs that could otherwise be used for public benefits as well as reducing the available funds for linkage and other such programs without accomplishing a reduction in GHG emissions. While NAIOP understands that BERDO's recent updates allowed for unrestricted RECs to be used for Power Purchase Agreements, these agreements are very challenging for a single real estate project, and therefore, this allowance in the Ordinance is not a practical solution for new construction. For these reasons, NAIOP strongly urges the BPDA to allow new construction to utilize non-geographically constrained RECs to achieve the City's carbon neutrality goals. ii. Market for Renewable Energy Credits - Given that such RECs are not practically available in the Commonwealth or the City, NAIOP is concerned with the feasibility of this recommendation and would urge the BPDA not to adopt this requirement. iii. Net-Metering and SMART Program - The interconnection issues and area network limitations may make solar infeasible in Boston unless the

Source	Comment Letter
	new zoning article allows for solar panels on buildings to count towards renewable energy requirements even if the energy credits are owned by someone else. Similarly for SMART program funded installations. NAIOP recommends that the new zoning article allow for participation in SMART programs. iv. Renewable Energy Investment Fund - NAIOP would like clarification regarding how such a fund can purchase RECs; implement off-site solar or wind projects; engage in community solar or other type programs, and generally work given the lack of land in Boston for off-site solar farms, etc. and the increasing difficulty of implementing solar farms given the local landscape, both socio-politically and physically.

Response

- Thank you for your and NAIOP's leadership, partnership, and support and the extensive and expert participation of your membership in the NZC process and on the TAG!

I. General Comments

- The ZNC recommendations and proposed policies anticipate adoption of the proposed standards, including application to both Article 80 Large and Small Project Review, simultaneously. The regulatory adoption timeline will be proposed in the next ZNC update.
- The proposed ZNC policies allow multiple solutions and strategies for achieving zero net carbon performance as well as flexibility for specific solutions.
- The City and BPDA are actively working with our local energy providers to ensure system capacities and conditions are expanded to accommodate new buildings and growth in Boston. Additionally, these efforts include advocating for better system resiliency and future readiness.
- Projects should continue to anticipate and include utility infrastructure improvements. The City and BPDA will continue to support projects and work with our utilities to ensure improvements are conducted in a timely manner and for reasonable costs.
- The building space impact and additional electrical infrastructure requirements are recognized.
- The ZNC framework prioritizes first) low carbon buildings, second) on-site renewable energy, and third) renewable energy procurement.
- The proposed framework, zoning, and policies anticipate ongoing updates to related codes and building industry standards. With the guidance of the proposed Advisory Board specific aspects of the proposed policies will be updated and revised as warranted.

Response

II. Low Carbon Buildings Technical Advisory Group Report

- The City has already approved numerous new development projects that employ the proposed ZNC framework, meet the proposed pCEI targets, and demonstrate the feasibility of the proposed practices. The proposed pCEI standards are defined as "targets" recognizing unique building conditions and uses could result in a project coming close but not meeting the appropriate target.

- The BPDA will continue sharing best practices including adding more ZNC projects to the Climate Resilient Building Case Study and is be happy to continue meeting with ABC members.

- Agreed; the proposed ZNC zoning and policies will achieving either of the two compliance pathways (comparative percentile reduction and use specific pCEI).

- The proposed building use specific pCEI targets listed in Table 1 are based on 2035 energy emission factors. ZNC Building performance targets reflect the potential of new construction building performance and are different from the BERDO targets which reflect the potential for improving older existing buildings.

- The proposed building use specific targets include both low-density and high-density house typologies. A per occupant standard was considered but not recommended.

- Agreed; projects may use either LEED or ASHRAE standards for modeling Baseline conditions.

- Agreed; the final recommendation is to raise the minimum LEED outcome to LEED Gold.

III. Onsite Renewable Energy Technical Advisory Group Report

- The City and BPDA will continue to assess the feasibility for Onsite Renewable Energy systems. Current project provided assessments continue to indicate solar PV is a highly feasible strategy for reducing carbon emissions, increase resiliency, and promoting local business and job opportunities.

- We will share the property tax credit for solar PV installations but do not feel it is necessary.

- Solar optimized is intended to ensure on-site renewable energy is considered and prioritized throughout the project planning process. The specific recommendations include area exceptions for access, safety, shading, and building mechanical systems, among others, that can reduce the solar area in part or entirely.

IV. Embodied Carbon Technical Advisory Group Report

- The proposed ZNC policies recognize the importance of reducing embodied carbon and the current state of industry practices and specifically recommends establishing an Advisory Committee to further advance embodied carbon strategies and policies.

Response

V. Renewable Energy Procurement Technical Advisory Group Report

- The proposed ZNC renewable energy procurement standards are aligned with those in the BERDO and will include future updates. Current and future BERDO regulation setting processes can best consider near and long term concerns and related updates to the REC standards and requirements.

- Agreed; the proposed ZNC policies allow for SMART program funded building solar renewable energy system installations.

- The proposed ZNC policies will include a grace period or extension for installation of proposed renewable energy systems and appropriate conditions to allow for resolving interconnection issues.

November 19, 2021

John Dalzell
Boston Planning and Development Agency
1 City Hall Square, #9
Boston, MA 02201

Dear Mr. Dalzell,

On behalf of A Better City's membership, representing 130 of Boston's business leaders across multiple sectors of the economy, thank you for the opportunity to comment on the Zero Net Carbon (ZNC) Building Zoning Initiative Technical Advisory Group (TAG) reports and recommendations. We are grateful for the City of Boston's continued climate leadership and for your engagement with business leaders through the initiative. We are committed to continuing to work with you to find implementable design and construction strategies that ensure the next generation of Boston's buildings align with city and state commitments to achieve net zero emissions by 2050.

As currently designed, however, we have significant concerns that the TAG recommendations for the ZNC Initiative are not feasible for the real estate and development community in Boston. We appreciate the goal to decarbonize new building stock but urge the BPDA to seriously examine the data utilized to design the Carbon Intensity Targets (CEI) and assess their applicability to the large commercial buildings that drive Boston's economy *before* recommendations are included in draft regulations. We also urge the BPDA to clarify key questions about the role of utilities in ensuring the large-scale deployment of onsite renewable energy, the relationship to evolving Commonwealth statutory requirements, and the workforce training and placement needed to implement this initiative.

Over the past two years, A Better City has engaged member businesses and institutions from A Better City and the Boston Green Ribbon Commission's Commercial Real Estate Working Group to form an Efficient and Resilient Buildings Coalition (Coalition). Members of my staff have simultaneously been members on two of the four TAGs and each TAG had representation from A Better City member companies with a total of twelve representatives across the four groups. Based on these discussions and feedback from Coalition members, please see the enclosed detailed comments on the recommendations of the four TAG reports. We look forward to continued dialogue in the months ahead as TAG recommendations are included in draft regulations.

Sincerely,

Richard A. Dimino
President & CEO

Enclosures: 1

cc: Michelle Wu, Mayor, City of Boston
Brian Golden, Director, Boston Planning and Development Agency
Richard McGuiness, Deputy Director, Boston Planning and Development Agency
Mariama White-Hammond, Chief of Environment, Energy & Open Space
Alison Brizius, Commission of Environment Department, City of Boston

DETAILED COMMENTS ON ZERO NET CARBON BUILDING ZONING INITIATIVE TECHNICAL ADVISORY GROUP (TAG) REPORTS AND RECOMMENDATIONS

November 2021

A Better City and its members support the City's goal of achieving net zero emissions by 2050 and recognize the urgent and important role new construction plays in achieving that. We appreciate that as the City seeks to implement building programs in line with this goal, the BPDA has selected consultants and sought stakeholder feedback on the Zero Net Carbon (ZNC) recommendations. We look forward to continued engagement as you refine the recommendations for inclusion in the draft regulations.

It is even more critical, therefore, that input from the real estate community be considered as you refine the Technical Advisory Group (TAG) recommendations ahead of regulation drafting for the ZNC Initiative. A Better City's Coalition members are eager to ensure that reasonable and achievable standards are set so that building owners and developers can both plan for and meet them once implemented. There are some overarching elements we believe need additional attention alongside specific TAG report recommendations. These are detailed below.

I. Overarching Elements for Additional Attention

A. Proof of Concept in Large Buildings

Our members have serious concerns about the feasibility of the Carbon Emissions Intensity targets and the requirement of forty percent emissions reductions compared to ASHRAE 90.1-2013. They do not believe these targets to be achievable; nor do they see examples of existing buildings that have met these reduction levels. We have previously expressed concerns that the buildings and costs in the Built Environment Plus report are not representative of large buildings in Boston constructed over 100,000 square feet, and do not adequately represent energy-intensive buildings like healthcare facilities, labs, data centers, etc.

As currently set, members are concerned that the targets could compromise industry practices such as daylighting and ventilation in commercial offices, compromise care and core services in hospitals and lab buildings, and make the development of housing cost prohibitive. They also noted concerns that an unrealistic standard invites the utilization of modeling tactics that will not actually result in the necessary reductions the BPDA is seeking. Finally, members questioned the approach to meeting carbon emissions standards through carbon limits and speculated if it would be more effective to pursue a standard that required electrification (perhaps with exceptions for life sciences and hospitals) and renewable energy procurement.

We recommend that the City carefully identify, examine, and share building-specific case studies and associated costs that demonstrate proof of concept in buildings of these types before drafting standards.

B. Consistency With Other Decarbonization Efforts

A Better City and its members are encouraged by action at the federal, state, and local levels to implement decarbonization policies and programs in line with commitments to do what science tells us is necessary. That said, members expressed concern that the current recommendations may jeopardize the future competitiveness of Boston relative to neighboring cities and the rest of the country.

It is imperative that these efforts, especially those between Boston and the Commonwealth are aligned to the greatest extent feasible. Uncertainty regarding evolving standards makes it difficult for building owners to plan and make

financial and operational decisions. For example, does the BPDA anticipate updating its percent carbon emissions reduction requirements upon promulgation of the new municipal opt-in stretch energy code currently under development at the Department of Energy Resources (DOER)? Or at a minimum, what process does the BPDA anticipate utilizing to determine the new stretch energy code's impact?

We recommend transparency about how a City of Boston Zero Net Carbon Zoning Ordinance is aligning with current policies under development in the Commonwealth including: 1) the state's new municipal opt-in stretch energy code under development at DOER, 2) updates to the current stretch and base building codes within the Board of Building Regulations and Standards, and 3) the anticipated work of the Clean Heat Commission. Considerations for alignment across these various initiatives will impact near-and medium-term implementation.

In addition, there is confusion about the relationship between the ZNC Zoning Initiative and the recently amended Building Energy Reporting and Disclosure Ordinance. There is a lack of clarity about thresholds for BPDA approval, how the buildings get treated in BERDO once occupied, and the timing and level of Alternative Compliance Payments.

We recommend the BPDA and Executive Office of Energy, Environment, and Open Space work together to develop clear communication for the real estate community about how the ZNC Zoning Initiative will get operationalized, and how it fits with the recently amended BERDO.

C. Integration into Article 80 Process

Each TAG report offers recommendations on timelines, review schedules, and enforcement mechanisms to comply with their respective proposals. We urge the BPDA to clearly outline requirements and consider the level of technical assistance needed to support the building industry in developing low-carbon buildings, maximizing on-site generation, procuring renewable energy, and reducing embodied carbon. This will assist the building community in determining their anticipated needs for compliance and help the BPDA ensure there is adequate staffing to promptly assist developers throughout the process.

In addition, renovations are mentioned for the first time in the TAG report under the Percent Emissions Reductions section. Given the complexities of the Article 80 Review Process, we urge the BPDA to clearly articulate early in this document the thresholds at which the ZNC standards will apply.

We recommend that the BPDA clearly outline the thresholds for the ZNC standard and how any final recommendations will come together into a process that developers will be expected to follow, and what support the BPDA will offer them.

D. Workforce Development

The TAG recommendations are designed to have sweeping impacts on how we design, source materials for, construct, and power buildings in Boston. Even with the refinements we are recommending, implementing a standard of this nature effectively will require a skilled workforce trained to routinely incorporate strategies for reducing carbon into their work. We know that, despite rapid change in the building sector in recent years, this remains far from the norm.

We recommend that the City of Boston prioritize workforce development and training opportunities, paying particular attention to providing access to career ladders in underrepresented communities in the City of Boston.

II. Technical Advisory Group (TAG) Report Recommendations for Additional Attention

A. Low Carbon Building TAG Report Recommendations

- As noted above, our members have serious concerns about the source data and rationale for the CEI and emissions reduction percentage targets. Members do not think the targets are realistic for large commercial buildings and lack the proof of concept in existing buildings. They also question if all the CEI targets appropriately include the ventilation requirements across all building typologies due to COVID-19, and the kind of resiliency/backup required in labs and health care institutions that are dominating construction. **We recommend convening a facilitated working session where information can be exchanged between members and BPDA, specific to the feasibility of the recommended targets.**
- Members noted that meeting LEED Platinum requires significant administrative burden and that Gold under LEED v4 is equivalent to LEED Platinum under v3. **We recommend LEED Gold as more appropriate.**
- The recently passed BERDO amendment ensured that data reporting requirements include a defined methodology for calculating emissions that allow for the most up-to-date and accurate emissions factors customized to generation sources serving the local grid in Boston. **We recommend the same data reporting requirements be included in the TAG recommendations to ensure alignment with BERDO and more accurate localized eGrid factors.**
- Under Section 2.4 Other Recommendations, the TAG recommends that the BPDA utilize practice data to annually update performance thresholds and targets. This pace is too rapid and will not allow any certainty for developers. **We recommend aligning with the BERDO update timelines of every five years. In addition, we recommend that the BPDA consider establishing a ZNC Standard Advisory Group to solicit industry input on the BPDA process for updating the thresholds, targets, and standard in future years.**

B. On-Site Renewable Energy TAG Report Recommendations

- For this component of the initiative to be successful, members stated that Eversource must be actively engaged and on-board to accept this level of interconnection. Member experience is that Eversource has resisted or reduced the size of all of their projects in the City. Therefore, they do not think the 12-month grace period will be sufficient. **We recommend the 12-month grace period be extended and/or linked to Eversource being at the table and approving projects. We also recommend clarity be provided about how compliance with the on-site renewable energy standard will be incorporated into the certificate of occupancy process.**
- We concur with the TAG recommendation that the City should offer support to project teams at the earliest stages of project planning. **We further recommend that the BPDA share details on how it plans to manage and staff this new case load to ensure developers have adequate support in meeting any final requirements.**
- Our members note that there will likely be instances of diminishing returns for projects constrained by limited roof space and that requiring them to pursue such installations will be administratively challenging and could lead to a misallocation of resources. The TAG report notes that the BPDA may allow for physical exemptions in certain cases. **We recommend the BPDA provide clarity about the conditions under which exemptions can be pursued and what the process for doing so will be.**
- At the Public Meeting the BPDA hosted in October 2021, a participant raised a question of whether the 50% capacity is for solar infrastructure or solar panels. **We recommend the BPDA clarify this important nuance in the ZNC Initiative language.**

C. Renewable Procurement TAG Report Recommendations

- Members expressed concern that Boston does not yet have a competitive Community Choice Aggregation option. They noted that in other markets they are able to pay a ten percent cost premium for 100% renewable energy, while Boston's cost premium of thirty percent, makes this an unviable pathway. **We recommend that BPDA pursue the possibility of the City offering a 100% renewable option that has a more reasonable cost premium than the current offering.**
- The Renewable Procurement TAG Report references a Cooperative Agreement multiple times. It is unclear if this agreement would be developed as part of a ZNC building or as part of BERDO compliance. **We recommend the BPDA clarify this important detail.**
- It is essential that developers have access to virtual power purchase agreements. While it is noted under the Renewable Energy Generators section that there is an exemption to the requirement for Massachusetts Class I generators for wind or solar generators located outside the ISO New England territory through VPPAs located in regions with electric grid emissions higher than New England's ISO, this exemption is not mentioned when describing requirements on pages 3 or 19. **We recommend the BPDA make the availability of this exemption clear whenever requirements are referenced in the ZNC Initiative language.**
- Members expressed confusion between the Renewable Energy Investment Fund and BERDO's Equitable Emissions Investment Fund. There was also lack of transparency around where funding from the Renewable Energy Investment Fund would be allocated. **We recommend that the BPDA clarify what, if any, relationship the Renewable Energy Investment Fund and BERDO's Equitable Emissions Investment Fund will have, and how funding from the Renewable Energy Investment Fund will be allocated. As in BERDO, we recommend annually publishing the disbursements from the Renewable Energy Investment Fund, and including this clause in the ZNC Initiative language.**

D. Embodied Carbon TAG Report Recommendations

- Developers in the City of Boston are much less familiar with embodied carbon reduction strategies than they are with low-carbon design, on-site renewable energy generation, and renewable energy procurement. Preliminary discussions with members indicate that assessment and measurement is required before requirements are advanced. **We recommend BPDA engage developers in further conversations on the feasibility of the TAG recommendations and what intermediate steps are necessary to test proof of concept, increase awareness, and develop markets to support the inclusion of embodied carbon in Boston's ZNC Zoning Initiative.**

III. Conclusion

We support Boston's leadership in pursuing Zero Net Carbon buildings and are eager to continue our engagement with the BPDA to ensure the Zero Net Carbon Zoning Initiative is a success. As a next step, we look forward to engaging in an information exchange on the source data and rationale for the CEI and carbon emissions reduction targets. We also encourage the BPDA to publicly report out on the comments received and how they will be incorporated into updated ZNC Initiative recommendations.

Should you have any questions regarding these comments or the ongoing engagement of A Better City members, please reach out to Yve Torrie (ytorrie@abettercity.org). We appreciate the opportunity to partner with you to support this critical work.

BOSTON SOCIETY FOR ARCHITECTURE

Boston Society for Architecture
290 Congress Street, Suite 200
Boston, MA 02210-1024

P: 617-391-4000
F: 617-951-0845
architects.org

November 19, 2021

Mayor Michelle Wu
1 City Hall Square
Boston, MA 02201

To Mayor Wu,

The Boston Society for Architecture (BSA) strongly supports the Boston Planning & Development Agency's (BPDA) Net Zero Carbon Building Zoning Initiative. Buildings have an important role in our society - they must be employed as a tool to solve the climate crisis, to protect us from extreme weather and to correct for social injustices. Climate action has become an imperative, and buildings, which represent the majority of emissions in Boston, are at the forefront of how we need to address this crisis. Sustainable design, once considered a fad is now the cornerstone of best practice, and continued leadership from the City of Boston, such as with the Net Zero Carbon Building Zoning Initiative, is needed to ensure all buildings are decarbonizing. The work of our members has shown net zero energy buildings are practical, affordable and possible for essentially every building type.

Net zero buildings improve public health by reducing combustion emissions, thereby reducing both indoor and outdoor exposure to carbon monoxide, particulates, NOx, SOx, and elevated CO2 levels. Net zero buildings also offer improved occupant health and comfort through greater control of Net Zero buildings also improve occupant health and comfort through greater indoor temperature control from increased insulation, enhanced humidity control via improved exhaust air energy recovery, improved indoor air quality due to filtered mechanical ventilation, and reduced risk of mold due to tighter envelope assemblies. Higher performing envelopes also provide passive resilience to extreme weather events and better balance glare to enhance natural light and views.

Studies, such as The Economics of Zero-Energy Homes (Rocky Mountain Institute), the Zero Energy Buildings in Massachusetts: Saving Money from the Start (Built Environment Plus), and the Massachusetts is Ready for Zero Net (Built Environment Plus) demonstrate that net zero buildings carry a negligible construction cost premium and result in significantly lower total cost of ownership. For example, 85% of responses spanning millions of square feet of buildings indicated net zero ready added less than 1% construction cost premium compared to business as usual designs. When building construction is financed through loans or bonds, net zero buildings typically save more in operating cost than the marginal uptick in loan or bond payments, resulting in positive cash flow from day one. Additionally, net zero and green buildings have enhanced asset value, reducing financial risk to developers looking to turn over properties.

Overall, the BSA strongly supports the current proposal. We also anticipate and support future enhancements that lower building emissions limits, update the energy model baseline, further develop embodied carbon standards, and broaden investment in overall sustainability, resilience and equity. The BSA would also like to offer more specific commentary on the following:

1. Low Carbon Buildings

BOSTON SOCIETY FOR ARCHITECTURE

Boston Society for Architecture
290 Congress Street, Suite 200
Boston, MA 02210-1024

P: 617-391-4000
F: 617-951-0845
architects.org

The BSA understands that the intent of the Zero Net Carbon Building Zoning is to be flexible, accommodating all building types, locations and owners. For example, the low-carbon buildings requirements allows higher-density facilities to comply through a percent reduction from the baseline, providing an exception to the absolute carbon emissions intensity (CEI). It may be helpful to clarify that there are two compliance pathways: *either* an absolute carbon emissions intensity (CEI) *or* a percent reduction from the baseline. This will ensure flexibility for buildings with lower density of use to comply via absolute CEI and those with higher density of use to comply using percent reduction.

Further, we believe the zoning should allow two baseline options: ASHRAE 90.1-2013 Stretch Code Baseline (without additional efficiency measures) *or* ASHRAE 90.1-2010 LEED Baseline. This will avoid additional energy modeling burden for smaller buildings that will comply with the LEED standard, but are not required to meet the Stretch Code. Allowing all buildings to use the ASHRAE 90.1-2010 LEED baseline will maintain fairness across all building sizes.

Clarifying the two compliance pathway options and the two baseline options will ensure that essentially all buildings have the ability to comply with the standard. We also trust that the City will allow flexibility for unique building types and circumstances that are not anticipated by the standard. Overall, we support the City's approach of raising the bar high and allowing some flexibility, rather than lowering the bar to the lowest common denominator.

2. Renewable Energy
Recognizing that on-site renewable energy will play a relatively small role in carbon emissions reduction, we applaud the requirement that off-site renewable energy meet additionality standards. This will ensure true net zero operational carbon in buildings.

3. Embodied Carbon
Embodied carbon represents the majority of carbon for new buildings over the critical next decade, particularly when they are required to have net zero operational carbon emissions. We commend the City of Boston for addressing embodied carbon in this zoning initiative, including requiring buildings to calculate their embodied carbon footprint and creating a technical working group to support and develop further goals around embodied carbon.

4. Broader Sustainability
We support the recommendation to raise the bar on LEED certification. Sustainability is not the singular topic of carbon emissions and it must holistically address human and environmental impacts at all scales. We support targeting LEED Platinum, assuming that there will be some flexibility for buildings such as smaller buildings with limited budgets or those on less optimal sites.

The pandemic has shown that public health and planetary health are critically linked. As climate change drives movement of animals and people, greater opportunities for exposure and virus mutation are anticipated. Meanwhile, climate scientists report that this decade is

BOSTON SOCIETY FOR ARCHITECTURE

Boston Society for Architecture
290 Congress Street, Suite 200
Boston, MA 02210-1024

P: 617-391-4000
F: 617-951-0845
architects.org

crucial for action, and that global emissions must be reduced to 50% below 1990 levels to avert the worst impacts of climate change. At the same time, our economy, temporarily paused by the pandemic, stands to benefit from a surge in new green jobs that new building standards will help to create. The City of Boston is proud to call itself a climate leader and the Net Zero Carbon Buildings Zoning proposal is necessary to maintain this status and to reach our climate goals.

Thank you for your consideration.

Greg Minott AIA
BSA President

Cc: Brian Golden, Director, BPDA

MEMBER INSTITUTIONS

Beth Israel Deaconess Medical Center
Boston Children's Hospital
Brigham and Women's Hospital
Dana-Farber Cancer Institute
Emmanuel College
Harvard University
- Harvard Medical School
- Harvard School of Dental Medicine
- Harvard T.H. Chan School of Public Health

Isabella Stewart Gardner Museum
Joslin Diabetes Center
Judge Baker Children's Center
Massachusetts College of Art and Design
Massachusetts College of Pharmacy and Health Sciences University
Massachusetts Department of Mental Health
Simmons University
Temple Israel
Wentworth Institute of Technology
The Winsor School

ASSOCIATE MEMBERS

Boston University Wheelock College of Education & Human Development
Fenway Community Health Center
Massachusetts Eye and Ear Infirmary
Merck Research Laboratories

November 19, 2021

Mr. John Dalzell
Sr. Architect for Sustainable Development
Boston Planning & Development Agency
One City Hall Square, ninth floor
Boston, MA 02201

RE: BPDA Zero Net Carbon Framework and Article 37 Update

Dear Mr. Dalzell,

Thank you for taking the time to meet with the healthcare, education, and cultural institutions in the Longwood Medical and Academic Area (LMA) this week for a briefing on the Zero Net Carbon Framework and Article 37 Update. This letter is in response to the Boston Planning and Development Agency's (BPDA) request for feedback on the framework and proposed regulatory changes that would apply to new buildings.

For background, MASCO members include several of the nation's top medical institutions, one of Boston's most revered museums, Harvard Medical School, Dental School and School of Public Health, the five Colleges of the Fenway, the largest Reform temple in New England, cutting-edge medical research organizations and a distinguished private high school. These institutions are drivers of the local economy, employing 68,000 people, educating 27,000 students, and treating 2.8 million patients each year. In addition, jobs in the LMA are growing at twice the rate of the state, adding 15,000 jobs in only ten years, and contributing one of every 11 new jobs in Boston over that time.

In the context of our members' patient care, teaching, and research missions, reducing energy usage and lowering emissions is critical to their core work. Our members are proud to have voluntarily implemented numerous energy conservation measures over the last several decades, and they continue to advance climate solutions and sustainability, whether through education, advocacy, or research. While there is more work to be done before we collectively reach our goals, the Green Ribbon Commission (GRC) reported this year that, even with significant growth, hospitals in Metro Boston have successfully reduced their greenhouse emissions by 18% between 2011 and 2019.

With this letter, we intend to provide a broad overview of the unique energy needs of the LMA, and to summarize some of the critical questions raised during this week's briefing. It is our hope that MASCO and its members can continue to engage with the BPDA over the next nine months as regulations are drafted. Our goal is that, together,

we can ensure these regulations are effective and attainable for the healthcare and education institutions in Boston.

We greatly appreciate your recognition of the challenges facing healthcare institutions where reliable energy supplies are critical to the mission of providing a front-line defense against the spread of infection and disease. We also appreciate that that carbon emission reduction target is reduced from 40% to 30% for licensed health care facilities that are not medical office buildings, as an effort to provide a somewhat more achievable target.

Our understanding of the current framework is that it is geared toward reducing carbon emissions in new standalone buildings. However, in the LMA many of our new buildings are in fact extensions of existing medical, research and academic complexes and as such they share energy systems and in the case of our medical institutions, they share a district energy plant. A critical question moving forward is how the proposed regulations will address these unique conditions for new buildings in the LMA.

A further consideration is the fact that the healthcare and biomedical institutions in the LMA, many of whom were represented on this week's briefing, are unique in that they receive all of their steam, and much of their electricity and chilled water from the Medical Area Total Energy Plant, or MATEP, the nearby privately-owned district energy plant that is fueled primarily by natural gas. As also noted by the GRC, even highly efficient district energy plants like MATEP ultimately will need to develop long-term decarbonization strategies if the City is to achieve its zero-carbon emission goals by 2050.

These are challenges that MASCO members look forward to working with the City of Boston to address as part of a working group that was established by the Boston City Council in BERDO 2.0 in recognition of the need for further analysis and research, and a dependence on future technological advances. Consistent with these considerations, MASCO recommends the BPDA consider the constraints in achieving carbon emission intensity targets faced by healthcare and biomedical institutions under long-term contracts with privately-owned district energy plants and the requirement to install and maintain onsite emergency backup generation to ensure safe and reliable operations and as a condition to receiving accreditation.

Similarly, one college in the LMA has an existing campus district energy plants, complicating their pathways to zero when it comes to considering renewables, VPPAs, and the feasibility of long-term RECs until their district energy plants become carbon neutral.

We thank you for the opportunity to provide initial comment, and we look forward to a continued, robust engagement with the BPDA. Please find attached a summary of questions raised during this week's briefing. I am available if there are any questions.

Sincerely,

Tom Yardley
VP for Area Planning & Development

Summary of Questions raised at 11/15 Briefing with MASCO Members via Zoom

ZNC Policy Framework

- The presentation notes that 100% fossil fuel free is not possible in the current technological climate, even in new construction. BERDO 2.0 has no compliance method to address this other than the Alternative Compliance Payment. This could prove to be very challenging for energy-intense sectors like laboratories and health care. What is the role of the Energy Investment Fund?

- Several members are tied to a district energy plant. We would like to better understand the alternatives and ramifications of building a new building under this scenario and how this may affect the CEI accounting.

- If we understood correctly, the new ZNC building standard is going to require new construction buildings to be net-zero from day one. Does this mean that even if the building meets the proposed carbon intensity targets, the owner must choose all-electric and either install renewables, contract for a PPA or buy RECs indefinitely until the grid reaches zero GHGs?

- If BERDO is a limit or net target, including the building minus renewable energy and procurement and ZNC is looking at CEI building emissions alone, then why does the ZNC policy framework include renewable energy procurement options?

Low Carbon Building

- We appreciate that the BPDA wants these goals to be aggressive but attainable. Are there any existing examples of healthcare buildings achieving 7.4 CEI? This poses a significant challenge, and we would like to work with BPDA to find viable solutions.

- It appears that the slide on the Landmark Center III includes 80% of the carbon reduction as coming from the purchase agreement. It would be helpful to clarify how this achieves the low carbon building goals.

- There needs to be consistency between what is proposed for both new (ZNC) and existing (BERDO) buildings and use the same reporting platform if possible.

- Can BPDA provide clarity on how ZNC regulations for new buildings would align with portfolio reporting for existing buildings under BERDO? In addition, can BPDA provide clarity on whether, once constructed, a new building can become part of a building owner's "existing building" portfolio for BERDO reporting and compliance?

- The proposed carbon accounting protocols add a layer of complexity for campus GHG inventories.
    - Green power contracts, for instance, are typically applied on a campus scale, not to individual buildings.
    - The GHG emissions factors the BPDA is using, especially for renewable energy procurement, appear to be different than what institutions use. We would be happy to work with BPDA on an approach to reconcile these.
    - According to the GHG reporting standards, if we procure renewables, we need to use a market-based scope two approach, not location-based (how does the ISO forecast relate to the BERDO factor set). It looks like BPDA is using more of a lifecycle GHG factor (a mix of scope two and scope three).
    - Portfolio Manager is not set up as a rigorous GHG tracking tool so it would be helpful ifthe BPDA developed a calculator, or another way to do this.
    - The MassSave incentives that we rely on to help pay for these projects will likely be using a different set of GHG factors since the state has mandated targets for them based on electricity produced within MA. (https://www.mass.gov/doc/greenhouse-gas-emissions-reduction-goal-for-mass-save/download)
    - It would be very helpful to see a real-world example of how the BPDA plans to apply this approach to a project from start to finish (i.e., energy model and purchased renewables x GHG factors, compared to current year and 5-year targets).

Renewable Energy Procurement

- How do the criteria for an acceptable VPPA differ from those used by BERDO? It will be very important for the BERDO 2.0 and the new ZNC regulations to interface seamlessly.

NAIOP
COMMERCIAL REAL ESTATE DEVELOPMENT ASSOCIATION
MASSACHUSETTS

November 19, 2021

Mr. Brian Golden, Director
Boston Planning and Development Agency
Boston, MA 02201

Re: NAIOP Comments on Technical Advisory Group Reports Regarding Zero Net Carbon Building Zoning Initiatives

Dear Director Golden:

NAIOP Massachusetts, The Commercial Real Estate Development Association, appreciates the opportunity to offer comment on the Technical Advisory Group Reports Regarding Zero Net Carbon Building Zoning Initiatives.

NAIOP represents the interests of members involved with the development, ownership, management, and financing of office, lab, industrial, mixed use, multifamily, and retail space in Boston and across the Commonwealth. We are grateful for the thoughtful stakeholder and technical advisory group process implemented by the Boston Planning and Development Agency (BPDA) and look forward to continuing our engagement on this topic.

NAIOP recognizes the importance of achieving Boston's carbon reduction goals and net zero carbon emissions by 2050. Climate change is an economic development, public health and environmental issue that affects every resident in the City of Boston. NAIOP offers the following comments and questions with the hope that the Zero Net Carbon Building Zoning Initiative program can be implemented successfully by providing clarity, consistency and predictability throughout the process while being grounded in technical expertise and technological feasibility.

I. General Comments

i. Implementation Clarity

NAIOP hopes the BPDA can provide clarity on the process for zoning implementation. Will the new Article be first implemented in Article 80 Large Project Review; 20,000 SF projects, matching the thresholds of the recently enacted BERDO 2.0 program; or will there be a stated time at which these requirements apply to all proposed projects in the City of Boston?

ii. Utility Considerations

In the development world, a proposed project often makes all efforts to beat or achieve a target in conceptual design, but there are often significant infrastructure challenges during implementation. **NAIOP urges the BPDA to consider these challenges and hopes that language can be adopted allowing alternative compliance in building operations to achieve carbon reduction goals** (such as including MEP connections and layout space for air-source heat pumps that can be run off electricity to replace a hot water boiler system).

a. While municipalities are consistently asking the development community for "low-carbon" / "all-electric" designs, the utilities consistently tell our members that they do not have the capacity to support such a project or they push for the developer to shoulder the cost of massive infrastructure upgrades.

   NAIOP understands the importance of achieving the City's carbon neutrality goals, but the development community cannot do it alone. **The industry needs help from the BPDA, City, and others to push the utilities to expand their capacity to support an all-electric built environment. NAIOP urges the BPDA not to hold developers accountable if the utilities are unable to provide the necessary capacity.**

   Additionally, **NAIOP would suggest that if infrastructure upgrades are required, those costs should offset other mitigation, or result in density bonuses.**

b. Often, to achieve electrification goals, additional transformers from the utility are needed. These additional transformers require significant space and often result in buildings having to dramatically expand the main electric room to achieve EV charging station requirements in the City of Boston – meaning that total building electrification will require an even larger dedicated space. Additionally, there is often pushback from the utilities, even with the existing EV parking requirements, regarding how many transformers they could actually provide to help the building owner achieve the mandate.

II. Low Carbon Building Technical Advisory Group Report

i. Case Studies

Based on feedback from professionals the City engaged to assist in developing the Low Carbon Building TAG Report, NAIOP is concerned that the case studies presented as precedent in the Report are not grounded in data gathered in Boston. NAIOP's members have expressed unease that the City directed the TAG to use the New Buildings Institute Report "Building Performance Targets and Building Prototype Profiles in Boston" and did not pursue modeling assumptions for occupant density, lighting power density and equipment power density based on different building types despite feedback from TAG members.

NAIOP encourages the BPDA to consider modeling assumptions based on building types to ensure all proposed projects in the City are entering the review process on an even playing field. Different building types do not only have different energy considerations, but also different federal and state level requirements to ensure public safety. For example, all hospitals are required to have energy generators on site to ensure patient care in the event of an outage. They are required to store enough fuel on-site to keep generators running for 96 hours. Lab buildings and even multifamily buildings often implement similar systems to ensure building integrity and user safety – and the loads are not the same for every building type. **By modeling Boston-specific assumptions for occupant density, lighting power density and equipment power density based on building type, best practices for the City can be ensured and the data can inform the development of practical, *achievable* standards for new projects.**

ii. Flexibility

The Low Carbon Building TAG report recommends that projects achieve both a 40% carbon emissions reduction below baseline ***and*** specific Carbon Emissions Intensity (CEI) targets. Upon review of several member projects and discussions with engineering teams, it is clear that **meeting both criteria is proving to be difficult, if not impossible.**

NAIOP strongly recommends allowing for flexibility when developing a path to compliance – achieving *either* the CEI *or* the percentage reduction. This approach will allow the City to achieve its carbon reduction goals while balancing the technological reality of buildings today. As currently proposed, NAIOP is concerned that responsible, sustainable and low-carbon development will simply stop, deeply impacting the City's tax base and competitiveness in the region.

a. Example: 500,000+ SF approved office building in the Back Bay is in design and ready to start construction in 2022. The project is able to achieve a 1.6 CEI (within the recommended target); ***however,*** it can only achieve a 31% carbon emission below baseline. The project is committed to being as sustainable as possible. It will push the envelope on carbon neutrality and will be one of the first all-electric office buildings delivered. **If NAIOP's proposed change is not adopted, future projects like this may never be built because of an inability to achieve the 40% reduction.**

b. Example: Approved 300,000+SF lab building that meets the 40% ASHRAE reduction, but not the CEI target. The project was approved by the City with this approach and will be one of the first core and shell lab buildings to meet the new reduction standard. **The proposed flexibility that the City has already implemented with this project should be allowed to apply to future proposed projects.**

iii. Carbon Emissions Intensity (CEI)

The CEI Targets illustrated in Table 1 of the report are the 2040-2044 standards. However, the report incorrectly references the 2035 Targets throughout.

NAIOP does not feel that a CEI target is appropriate for housing typologies as energy use (or carbon) per square foot metrics will reward projects for having less density, as less units will equal less energy use per square foot. Rather**, NAIOP proposes a percentage reduction compared to ASHRAE or carbon emissions per occupant standard**, as we believe this is more appropriate for encouraging density and efficiency at the same time.

iv. Baseline

The report recommends that projects meet 40% carbon emissions reduction compared to an ASHRAE Standard Baseline. However, to ensure flexibility for design and development, **NAIOP recommends that the design teams be allowed to select LEED standards as the Baseline *or* ASHRAE.**

Many buildings under 100,000 SF do not fall under the Stretch Code, but in the City of Boston are required to meet LEED per Article 37. In the field, LEED v4 projects typically perform an energy model per ASHRAE 90.1-2010. Therefore, **NAIOP believes that to ensure fairness and flexibility, all proposed projects should be allowed to choose to**

either use the current 2018 Stretch Code baseline (with no additional efficiency measures) or the LEED baseline.

v. LEED

While all projects may have a target of LEED Platinum, it is often impossible to achieve from both a technological and cost standpoint. **NAIOP would recommend the BPDA consider setting a point target rather than a Platinum target, and is happy to discuss this further with the BPDA team to ensure a target that balances development flexibility with carbon reduction targets.**

III. Onsite Renewable Energy Technical Advisory Group Report

i. Financial Analysis of Case Study 1 Regarding Labs

NAIOP is concerned that this case study does not adequately demonstrate the total capital installation cost assumption. As reported, the cost assumption of $2.50/Watt does not take into account additional costs for supporting electrical equipment, added labor costs due to electrical install, potential added structural needs, additional consulting, etc. **NAIOP urges the BPDA to revisit this cost assumption and do additional analysis to ensure accuracy, as these assumptions will be used to inform the policy development process.**

ii. Solar Photovoltaic (PV) Systems

If developers and property owners are required to install PV systems, **NAIOP hopes the City will consider an immediate benefit to defer the initial cost of the solar system**, and hopes that, as discussions continue with the new Mayor and her administration, the BPDA will **recommend an immediate property tax credit applicable to the year of installation set at a percentage of the initial capital cost.**

iii. Solar Optimization and Urban Design

The Report states "Solar optimization and building and urban design options and priorities are to be equally considered" (p. 3). NAIOP is concerned with this statement, give that this is not achievable when there are required shadow restrictions, wind considerations, mechanical noise issues and other competing priorities the project proponent must be responsive to during the design, review and permitting process. How does the BPDA plan to manage these competing priorities? For example, will the City accept a worse shadow condition or worse wind condition for the incorporation of solar? **NAIOP urges the adoption of language that clarifies how such situations will be managed.**

IV. Embodied Carbon Technical Advisory Group Report

Reuse of existing buildings with building renovations that meet current energy codes (and stretch codes where applicable) is the best way of saving energy in a macro sense. However, NAIOP does not believe that there is enough data available to determine from a net-zero viewpoint if it is better to tear down an existing building and build a new one to achieve carbon neutrality**. NAIOP urges the adoption of language that recognizes the savings from the reuse of existing buildings, the salvage of materials etc. in calculations of carbon neutrality and compliance with the new zoning Article.**

V. Renewable Energy Procurement Technical Advisory Group Report

i. Massachusetts Class 1 RECs Requirement

The Renewable Energy Procurement TAG report recommends that:

> *"All off-site renewable energy procurement must satisfy three minimum requirements:(1) the generator must qualify as a Massachusetts Class I generator as defined by the Massachusetts Department of Energy Resources (DOER)3, (2) RECs must be retired on behalf of the ZNC building, and (3) the annual purchase commitment must be validated via the Building Energy Reporting and Disclosure Ordinance (BERDO)."*

NAIOP understands that alignment with the recently updated Building Energy Reporting and Disclosure Ordinance (BERDO) is critical to a successful implementation of the Green Zoning Article and appreciates the BPDA's desire to ensure buildings are not out of compliance with the BERDO program upon completion. **However, NAIOP has significant concerns with this recommendation.**

There is a fundamental divergence between the Ordinance's requirements for existing buildings and what this recommendation would mean for new building design and development. The updated BERDO requires purchasing of incremental amounts of power over time. Zero net carbon buildings must offset all of their power with renewable energy certificates. Massachusetts Class 1 RECs cost eight to ten times more than green e-certified non-geographically constrained RECs and requiring all new buildings in the City to buy them will cause an additional price spike. **This recommendation, if adopted, will result in significant additional costs that could otherwise be used for public benefits as well as reducing the available funds for linkage and other such programs without accomplishing a reduction in green house gas emissions**.

While NAIOP understands that BERDO's recent updates allowed for unrestricted RECs to be used for Power Purchase Agreements, these agreements are very challenging for a single real estate project, and therefore, this allowance in the Ordinance is not a practical solution for new construction.

For these reasons, NAIOP strongly urges the BPDA to allow new construction to utilize non-geographically constrained RECs to achieve the City's carbon neutrality goals.

ii. Market for Renewable Energy Credits

According to the report, building owners and developers will be directly competing with utilities to purchase renewable energy credits (RECs). **Given that such RECs are not practically available in the Commonwealth or the City, NAIOP is concerned with the feasibility of this recommendation and would urge the BPDA not to adopt this requirement.**

iii. Net-Metering and SMART Program

The report outlines the interconnection issues and area network limitations in Boston. These limitations may make solar infeasible unless the new zoning article allows for solar panels

on buildings to count towards renewable energy requirements even if the energy credits are owned by someone else. **It is critical that this allowance is included** to ensure practical achievability of building requirements and the City's carbon neutrality goals.

Similarly, in the SMART program, the renewable energy credits are assigned to the utility. **NAIOP again recommends that the new zoning article allow for participation in SMART programs to count towards the requirements.**

iv. Renewable Energy Investment Fund

NAIOP would like clarification regarding how such a fund can purchase RECs; implement off-site solar or wind projects; engage in community solar or other type programs, and generally work given the lack of land in Boston for off-site solar farms, etc. and the increasing difficulty of implementing solar farms given the local landscape, both socio-politically and physically.

Boston is a unique city, both in terms of its history, but also in the pressures it faces on housing production, job creation and redevelopment due to its compact footprint. NAIOP believes that the City and the development community should continue to work together to ensure an appropriate balance, and further urges the City and the BPDA to reject policy proposals that are impossible to achieve, discourage housing production and economic investment, and negatively impact the City's critical commercial tax revenues.

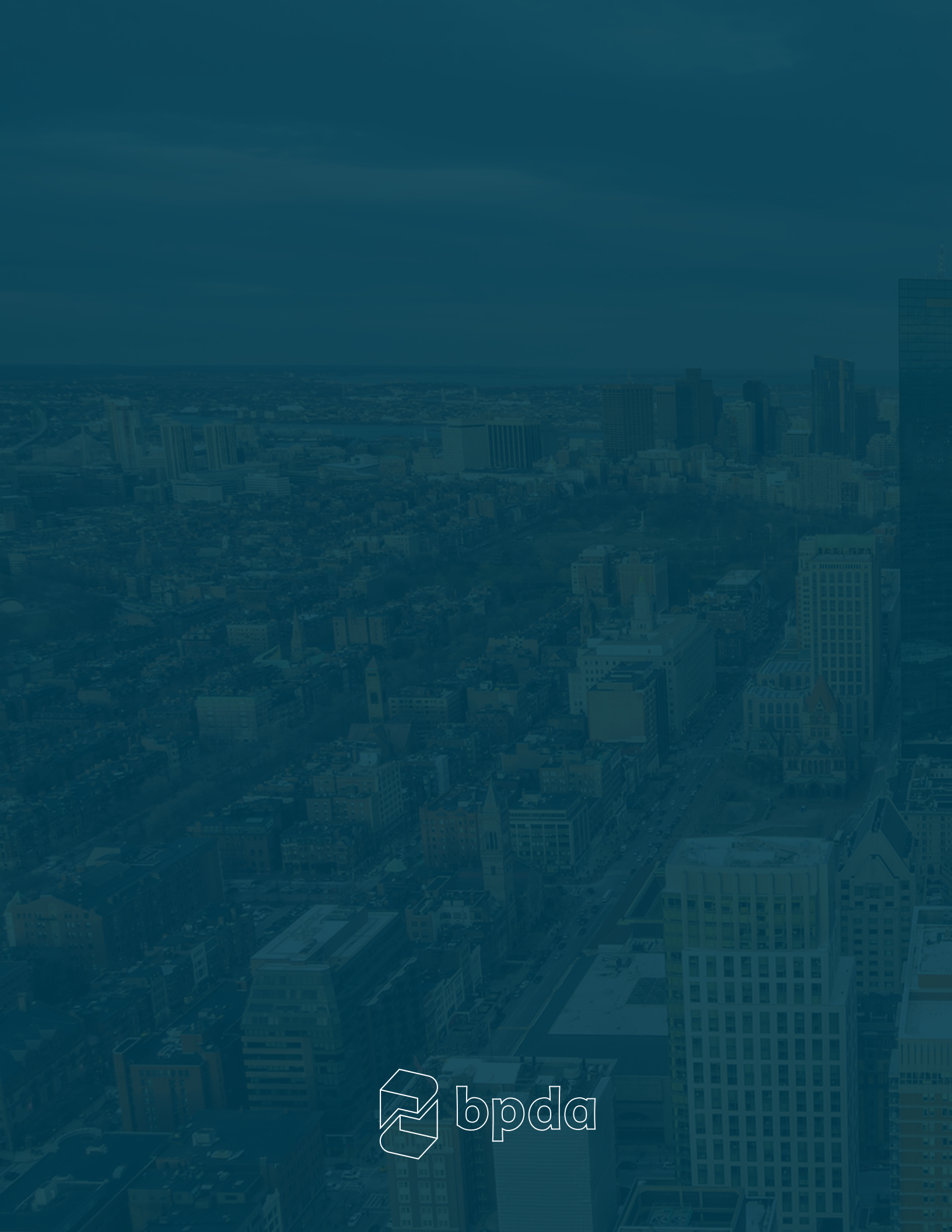
Thank you for your consideration of our comments. We look forward to continuing to collaborate with the BPDA on this critical issue. Please contact me if you have any questions or if additional information is needed.

Sincerely,

Tamara C. Small

Tamara C. Small
Chief Executive Officer
NAIOP Massachusetts, The Commercial Real Estate Development Association

CC:
Alison Brizius, Commissioner, Environment Department, City of Boston
Mike Christopher, Interim Director of Development Review, Boston Planning and Development Agency
John Dalzell, AIA, LEED Fellow, Boston Planning and Development Agency


bpda