Boston Zero Net Carbon: Green Building Zoning Recommendations DRAFT

Prepared for
Boston Planning & Development Agency (BPDA)
John Dalzell
john.dalzell@boston.gov

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

October 20, 2021

Thornton Tomasetti

BR+A

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 prodUrement, 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)
- Compatible with upcoming BERDO 2.0 emissions performance standard
- In line with best-in-class new buildings in New England for performance targets

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. 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. This data is being used to develop an upcoming set of CEI limits for for buildings of at least 20,000 square feet and residential buildings with 15 or more units, mimicking NYC. If adopted, all applicable buildings would have to reduce greenhouse gas emissions to zero through a combination of clean energy, conservation, and carbon offsets to reduce their emissions to zero.

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 and current carbon emission factors as published by BERDO.
- 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: BERDO-Aligned 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), in alignment with the 5-year periods within the BERDO program.

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.

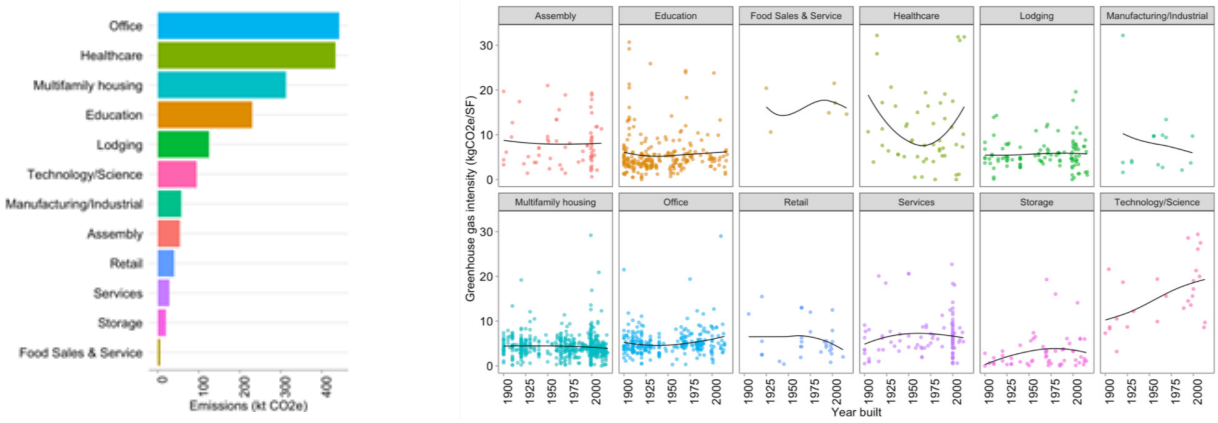

Figure 1. Total 2018 carbon emissions per building typology in Boston (left), Total carbon emissions per year of construction and per building typology (right). Source: Synapse model using BERDO data.

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.

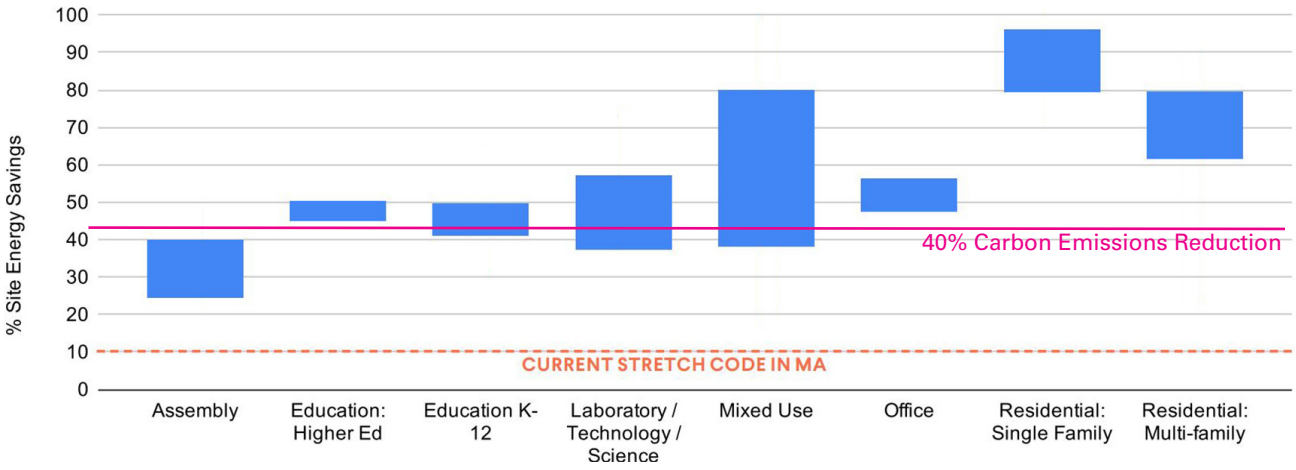

Figure 2: Percent Site Energy Savings with respect to ASHRAE Standard 90.1-2013 for 100+ MA buildings designed to be Net Zero Energy or Net Zero Ready, before discounting renewable neergy generation. Note that all buildings within the Assembly category are smaller than 20,000 sf and thus not applicable 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 expanding the BERDO data collection system to the zoning stage stage, so that one process can dovetail into the other in one consistent workflow, enabling the BPDA and the public to study the links between predicted and actual performance.