**DRAFT 4-23-25**

**All numbers in this document are preliminary and are here only for the purpose of illustration. Scenarios are also made up. You (ZEAB) are expected to correct them**

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# Commercial Working Group

## Initiative: NEW CONSTRUCTION

Introduction

Buildings are Massachusetts’ second-largest source of greenhouse-gas pollution, responsible for about 35 percent of combined residential and commercial emissions. Decarbonizing this sector is necessary to meet the legally binding climate limits in the 2025/2030 Clean Energy & Climate Plan and Brookline’s own net-zero goals. Every new structure permitted today will be on the town’s ledger for 50 to 100 years. Insisting that it be ultra-efficient and all-electric from day-one will eliminate decades of carbon pollution that would require costly retrofits later. [Mass.gov](https://www.mass.gov/info-details/2023-massachusetts-climate-report-card-buildings-decarbonization)

Brookline has positioned itself as a climate leader by voting at the January 10, 2023 Special Town Meeting to opt in to the state’s Municipal Specialized Energy Code, which tightened the existing Stretch Code and, for multifamily projects larger than 12,000 ft², effectively requires Passive House performance or all-electric design starting July 1 2023. Leveraging that decision through proactive incentives, streamlined permitting and technical assistance for high-density, high-efficiency projects will turn policy on paper into measurable emission reductions. [Brookline, MA](https://www.brooklinema.gov/DocumentCenter/View/38319/Combined-Reports-January-10-2023-Special-Town-Meeting-with-Supplements)

Density itself is a climate tool. A U.S. EPA analysis shows that residents of multifamily, transit-oriented developments use 40–60 percent less household and transportation energy per capita than those in conventional suburban single-family homes, primarily because shared walls cut heating and cooling losses and because robust transit, walking and cycling options reduce vehicle miles travelled. [US EPA](https://www.epa.gov/sites/default/files/2014-03/documents/location_efficiency_btu.pdf) Encouraging compact, mixed-use projects near Brookline’s Green Line stops and commercial corridors will lower building and transportation emissions while preserving scarce open space.

Pairing dense new construction with Passive House or similar net-zero standards multiplies the benefits: airtight envelopes, heat-recovery ventilation and super-insulation typically cut space-conditioning loads by 70-90 percent, which can be met by small heat-pump systems powered by an ever-cleaner regional grid. Massachusetts data show that the construction-cost premium for certified net-zero-ready projects has fallen to under one percent for many multifamily buildings, making deep efficiency a cost-effective hedge against rising energy prices. [Built Environment Plus](https://builtenvironmentplus.org/new-report-shows-massachusetts-is-going-net-zero/?utm_source=chatgpt.com). Anecdotal evidence from the developer community suggests that this is an aggressive estimate and that real costs for certified net-zero are between 5 and 10% more expensive.

New construction is not the only or best path to decarbonization. Retrofitting existing buildings is, in many cases, the preferred route. While new construction offers significantly better operating efficiency than even a deep retrofit, the whole-life carbon cost needs to be considered, and new construction has a significant initial carbon footprint.

This document explores when and if new construction should be prioritized and supported by the town, based on existing frameworks and industry practices, the expertise of ZEAB and the Sustainability and Natural Resources division of the Town of Brookline, and in consultation with the Preservation Commission.

Most reference material uses 60 years as the modelling window when comparing tear down and rebuild vs retrofit. This is, however, a modelling window and not a guideline – in essence if a tear down and rebuild does not have better WLC than a retrofit over 60 years then it is unquestionably unacceptable. Brookline needs to do better than that, and the general guidance seems to be a 30-year WLC break-even target, or one which is in line with a local or regional goal e.g. the MA 2050 goal or the Town 2040 goal. For the purposes of this draft, we are choosing a 25-year break-even target, more aggressive than the general guidance, and in line with MA goals.

Setting a goal of 25-year break-even is abstract. We should understand what that might mean in the context of a typical Brookline house. Data show that a tear down and rebuild of a wood-built two-story single-family house will not achieve our break-even goal – we would need more density. For example, preliminary calculations suggest that to meet our 25-year break-even target we need to build a four-story passive house with 3-3.5 higher gross floor area to replace our wood-built two-story single-family house.

We must also consider the financial practicality of new construction – will developers make a profit? If they do not, they will not build, and whatever goals Brookline or the State has, environmentally or otherwise, will not be met. Again, density is the answer. In this case, environmental concerns and developer needs can align, under the right circumstances.

Brookline policy plays a part – Brookline has a demolition delay ordinance which is designed to slow down new construction to preserve our historic buildings. This ordinance deliberately discourages development, where we might, under certain circumstances, want to promote development. The current demolition delay ordinance does not allow for environmental mitigation to bypass the demolition delay. We propose that, working in coordination with the Preservation Commission and the Town’s Preservation Planners, we introduce environmental mitigation that will allow by-right bypassing of the demolition delay for new construction where that new construction can show that it meets stringent environmental requirements.

Passive housing offers significant energy efficiencies over deep retrofits – they are approximately 75% more efficient. That means that even with a 3x higher density passive housing will have a lower impact on our electrical grid than existing housing lowering our aggregate electrical need. And new construction may offer more opportunities to install the new transformers that are needed to increase our electrical supply and meet our net zero goals.

Promoting high-density, high-efficiency new construction aligns Brookline with state and federal incentives (e.g., Mass CEC Passive House incentives, IRA tax credits and DOE’s New REAP grants), attracts mission-driven owners and developers, and delivers co-benefits that our community values: healthier indoor air, quieter homes, resilience during grid outages, and more diverse, transit-accessible housing choices. By embedding these principles in zoning, permitting and financial-support programs, the Zero Emissions Advisory Board can secure one of the most cost-effective pathways to Brookline’s zero-carbon future while advancing equity and livability.

Finally, a zero-emissions strategy that relies exclusively on retrofits is very unlikely to be successful – homeowners and landlords cannot be compelled to retrofit their buildings; policies like BERDO can only do so much; community-based campaigns have limited impact. Supporting environmentally responsible new construction as part of a broader strategy is the only way that Brookline will meet its climate goals

Overall Goals

1. Support and encourage high-density, high-efficiency (Passive-House) buildings where appropriate
2. Achieve a 25-year WLC break-even for new construction compared to retrofits.
3. Align zoning and permitting with state/federal sustainability incentives.
4. Balance development with historic preservation through environmental mitigation.

Assumptions

1. Ultra-efficient designs are more cost-effective than retrofits over time.
2. The Brookline residential and commercial real estate market will remain strong.
3. State incentive programs will remain in effect, even if federal programs are cut back.
4. The grid will become cleaner over time, in line with current MA net zero emissions goals.
5. That the MBTA remains a reliable alternative to personal or autonomous vehicles.

### Political Landscape

TBD

### Unlock climate-positive *new* development

| **Strategy** | **What It Does** | **Practical next step** |
| --- | --- | --- |
| **Expand & refine the MBTA-Communities Multifamily Overlay** | Brookline met the *minimum* transit-oriented zoning mandated by Mass. G. L. c.40A §3A in fall 2023. Increasing as-of-right density, building height (6–8 stories), and size of the relevant zoning districts for Passive House projects multiplies the law’s climate and housing benefits. [Mass.gov](https://www.mass.gov/info-details/multi-family-zoning-requirement-for-mbta-communities?utm_source=chatgpt.com); [Brookline, MA](https://www.brooklinema.gov/1479/Zoning-By-Laws-and-Guidelines) | Direct Planning Board to model additional bylaw provisions and overlay districts within the walkshed ( ½ or ¼ mile to MBTA); present warrant article to Town Meeting. |
| **Introducing environmental mitigation to demolition delay bylaw** | Allows by-right avoidance of the demolition delay for new construction that meets stringent environmental guidelines co-developed with the Preservation Commission | Work with the Preservation Planners and Preservation Commission to come up with acceptable guidelines for environmental mitigation. |
| **Replace “single-family” districts with a simple Neighborhood Residential zone** | Minneapolis’ 2019 abolition of single-family zoning unlocked thousands of duplexes/triplexes with negligible neighborhood disruption and a measurable rise in housing supply. [Wealth Management](https://www.wealthmanagement.com/real-estate/what-happened-when-minneapolis-ended-single-family-zoning-justin-fox?utm_source=chatgpt.com) | Draft zoning amendment that lets up to 3–4 units by right town-wide, with a half-space per unit parking maximum or required EV charging, and Passive House compliance. |
| **Density bonuses for verified net-zero performance** | Offer extra floor-area ratio (FAR) or one additional story when a project commits to PHIUS+/zero-carbon design—an approach already used in Somerville and Acton. [concordma.gov](https://concordma.gov/DocumentCenter/View/27436/MA-Sustainable-Buildings-Case-Studies?utm_source=chatgpt.com); [Local Housing Solutions](https://localhousingsolutions.org/housing-policy-library/density-bonuses/?utm_source=chatgpt.com) | Add a FAR bonus table to §5.06 Multifamily Overlay and §5.09 Major Impact Review.  Set a limit on the number of density bonus permits per year each with a cost of $10,000. Permit numbers and cost adjustable by the Select Board every 5 years |
| **Eliminate parking minimums within a quarter-mile of Green Line & key bus routes** | Structured parking can equal 20% of a project’s embodied carbon; right-sizing or removing it frees capital for deeper efficiency and lowers rents. | Amend §6.02 to set maximums, not minimums, in TOD sub-districts, or require EV charging; combine with a shared-mobility pass requirement. |
| **Amend Public-Benefit Zoning Incentives to Prioritize Sustainability** | Updates Article 5.32 (height bonuses) and tightens Article 5.21 (FAR bonuses) so that *specific* high-impact sustainability measures—e.g., on-site solar PV sized to ≥60 % roof coverage, geothermal or ground-source heat pumps, Passive House certification, or carbon-sequestering materials—qualify as recognised “public benefits.” Aligns Brookline’s incentive menu with its adoption of the Municipal Specialised Energy Code and participation in the DOER Fossil-Fuel-Free pilot, ensuring that height/FAR concessions directly advance net-zero goals rather than generic amenities. | During the ongoing Comprehensive Plan process, instruct Planning staff to draft warrant-article language that: 1. Inserts a new subsection in §5.32.2 explicitly listing “Verified on-site renewable energy generation, high-performance building certification (PHIUS, ILFI Zero Carbon), or district-scale geothermal infrastructure” as eligible public benefits. 2. Mirrors that list in §5.21 and the Design Guidelines’ Counterbalancing Amenities matrix. 3. Defines minimum performance thresholds (e.g., kW of PV per ft², PHIUS+ certification). Hold joint Planning Board/ZBA hearing by September 2025 and seek Town Meeting adoption in November 2025. |
| **One-stop “Climate-Ready” permit track** | A dedicated staff reviewer guarantees decisions in ≤90 days for projects that meet density, Passive House, and affordable-housing targets—reducing soft costs and providing developers with certainty. | Approve fee waiver schedule; allocate ARPA or Green Communities funds for staff. |
| **Mandate on-site solar for mid-/large new buildings** | Requires every new building ≥ 10 000 ft² *or* ≥ 10 dwelling units to install photovoltaic (or solar-thermal) collectors sized to the lesser of **(a)** 1 W per ft² of conditioned floor area **or** **(b)** ≥ 60 % of the solar-suitable roof/garage deck. Mirrors Watertown’s 2019 ordinance—which covers the same thresholds and 50 % roof coverage—and advances Cambridge’s Net Zero Action Plan item 3.2.1 from a “solar-ready” standard to full installation. Expected to cut each project’s operational emissions by ~5–15 %, hedge residents against future electricity price spikes, and add micro-grid resilience when paired with storage. Exclusions should be allowed where solar is impractical or inefficient but the developer should be required to make a payment per square foot or install backup batteries [MMA](https://www.mma.org/watertown-ordinance-requires-solar-panels-on-commercial-buildings/); [Welcome to the City of Cambridge](https://www.cambridgema.gov/~/media/Files/CDD/Climate/NetZero/2021planupdate/netzeroactionplan5yearupdatereport.pdf) | Draft a new §5.\_\_ “Solar Generation Requirement” in Brookline zoning: **(1)** spell out applicability, sizing formula, and a performance-based waiver for demonstrably shaded sites; **(2)** require submittal of a PV production model during design review; **(3)** allow an off-site community-solar payment–in-lieu only when on-site is infeasible. Charge Planning staff with producing warrant article language by August 2025, hold joint Planning Board/ZBA hearing in September, and seek adoption at November Town Meeting. |

### Let *existing* neighborhoods evolve responsibly

| **Strategy** | **What It Does** | **Practical next step** |
| --- | --- | --- |
| **Accessory Dwelling Units (ADUs) 2.0** | Brookline’s 2024 by-law already loosened ADU requirements. Allowing ADUs *by right* up to 1,200 ft², eliminating the owner-occupancy requirement, and providing design support spurs gentle infill. [Brookline News](https://brookline.news/town-meeting-votes-to-ease-restrictions-on-adus/?utm_source=chatgpt.com); [Brookline for Everyone](https://brooklineforeveryone.com/2024/11/25/town-meeting-recap-b4e-holiday-party-and-thanksgiving-reading/?utm_source=chatgpt.com) | Adjust §4.05 and issue pre-approved Passive House ADU plans and connect homeowners to Mass Save heat-pump rebates. |
| **Single-family-to-two-family conversion permit** | Article 8 (Nov 2024) created a special-permit path. Improves that by permitting conversion *by right* for properties within a half-mile of transit, conditioned on electrification and a minimum HERS 0/PHIUS level. [Brookline for Everyone](https://brooklineforeveryone.com/2024/11/25/town-meeting-recap-b4e-holiday-party-and-thanksgiving-reading/?utm_source=chatgpt.com) | Adjust §4.07 Table of Use Regulations; set design guidelines to preserve street-facing façade. |
| **Adaptive-reuse overlay for aging strip retail & surface lots** | Prioritises Commonwealth Ave., Boylston St. frontage, and hospital parking lots for 5- to 7-story mixed-use redevelopment with ground-floor grocery/retail, daycare slots, and bike-hub amenities. | Commission parcel-level feasibility study; negotiate district-scale energy or sewer upgrades via development agreements. |
| **Transfer of Development Rights (TDR) from historic or tree-canopy parcels** | Lets owners of protected lots sell unused FAR to Transit Oriented Development corridors, concentrating growth where services already exist while funding preservation. | Insert TDR provisions into §5.21 FAR regulations and map sending/receiving areas. |
| **Green PACE + property-tax abatement for deep retrofits** | Offers 20-year, off-balance-sheet financing and partial tax relief for gut rehabs that create ≥3 units, electrify, and hit Net-Zero Ready. | Partner with a local bank and MassDevelopment to market PACE; adopt local tax-increment exemption similar to Somerville’s 121A program. |

### Add a climate lens to every special-permit decision

| **Strategy** | **What it does** | **Practical next step** |
| --- | --- | --- |
| **Amend §9.05 to add a “GHG & Climate Impact” finding** | Inserts a new ¶ f: *“The development, as proposed, will minimize lifecycle greenhouse-gas emissions and support Brookline’s net-zero by 2040 goal.”* • Gives the ZBA clear authority to **deny or condition** projects based on modeled operational + embodied carbon. • Aligns Brookline with Boston’s Article 37 Green Building Review and Cambridge’s Article 22 Net-Zero Narrative, which already require carbon-intensity calculations for major projects.​[City of Boston Planning Department](https://www.bostonplans.org/planning-zoning/planning-initiatives/article-37-green-building-guidelines?utm_source=chatgpt.com)[Welcome to the City of Cambridge](https://www.cambridgema.gov/CDD/zoninganddevelopment/developmentreview/specialpermits/greenbuildingrequirements?utm_source=chatgpt.com) | 1. Ask Planning staff to draft a warrant article that: • adds the new finding to §9.05(1); • lets the Board attach carbon-related conditions under §9.05(2). 2. In the same article, cross-reference **§5.09 Design Review** so that “Major Impact” projects must file a *Carbon Impact Statement* (energy model + embodied-carbon estimate) using Mass CEC or LEED LCA tools. 3. Hold joint Planning Board/ZBA hearing by August 2025; target adoption at November Town Meeting. |
| **Publish technical rules & thresholds (“Brookline Climate Review Guidelines”)** | Provides applicants and peer reviewers with:  • EUI and Carbon Intensity targets by building type; • accepted modeling software (TREAT, PHPP, etc.); • required mitigation hierarchy (reduce load → electrify → renewables → offsets). | Develop guidelines in Q1 2026 with assistance from MassCEC and local design firms; approve by Planning Board vote so they can be updated administratively as technology improves. |
| **Offer a fast-track/fee reduction for projects that beat the target by ≥20 %** | Rewards best-in-class projects and eases staff workload. Developers get predictability and modest savings; the Town gets deeper cuts without mandating them. | Embed this incentive in the Planning & Inspections fee schedule once §9.05 is amended. |

## Baseline Data and Sample Scenarios

Our assumptions are:

1. That all new construction will have 3x the density of existing buildings on average.
2. That all new construction will have 30% of the energy consumption of existing buildings
3. That all new construction will be fossil fuel free
4. That all new construction will have a WLC payback within 25 years

#### Today- 2025 Baseline Data:

#### Sample Scenarios:

2040 Target **High**:

* 500 passive units per year
  + 150 new single family to passive two family units per year
  + 350 new passive units in apartment buildings
* $5M in annual permit revenue to the Town yearly, and $75M in aggregate
* By 2040 we would:
  + Replace 2500 existing units with 7500 new units
  + We would see a reduction in needed electrical supply of 75M kWh/Year

2040 Target **Med**:

* 200 passive units per year
  + 50 new single family to passive two family units per year
  + 150 new passive units in apartment buildings
* $2M in annual permit revenue to the Town yearly, or $30M in aggregate
* By 2040 we would:
  + Replace 1000 existing units with 3000 new units
  + We would see a reduction in needed electrical supply of 30M kWh/Year

2040 Target **Low**:

* 100 passive units per year
  + 50 new single family to passive two family units per year
  + 150 new passive units in apartment buildings
* $2M in $1M in annual permit revenue to the Town yearly, or $15M in aggregate
* By 2040 we would:
  + Replace 500 existing units with 1500 new units
  + We would see a reduction in needed electrical supply of 15M kWh/Year

2050 Target

### Climate impact

* Passive House construction reduces heating energy by ~75% vs. retrofits, ~85% vs. unrestored homes.
* 25-unit Passive House apartment cuts community heating demand by 73% compared to five single-family homes, saving ~70 t CO₂-e/year.

### Financial ROI

### Cost / Ton of GHG:

### Feasibility

### Data

Strategies from other municipalities to consider:

## Appendix A – Heating-energy comparison for a 2 000 ft² single-family home in Brookline, MA (Climate Zone 5A)

| **Performance level** | **Typical annual space-heating demand\*** | **Peak design heating load (coldest hour, -2 °F design temp)** | **What that means in practice** |
| --- | --- | --- | --- |
| **New-construction Passive House** (meets PHIUS 2021 criteria for Boston) | **≈ 9 – 11 million Btu/yr** (≈ 2 700 – 3 200 kWh/yr) | **≈ 4–5 kBtu/hr** (≈ 1.2–1.5 kW) | A single 9 000 Btu/h ductless mini-split (or small ducted heat-pump) covers the whole house; no backup strip heat needed. |
| **Historic 1900-1930 house, deep-energy retrofit** (dense-pack cellulose in walls, R-60 attic, new windows, blower-door ≤ 2 ACH50) | **≈ 35 – 45 million Btu/yr** (≈ 10 000 – 13 000 kWh/yr equivalent) | **≈ 15–18 kBtu/hr** (≈ 4.5–5.3 kW) | Needs a 1- or 1.5-ton heat-pump per floor **or** a 40 kBtu/h modulating gas furnace; supplemental electric strip heat on the few polar nights. |
| **Historic house before retrofit** (original plaster walls, knob-and-tube cavities, single-pane storms) | **≈ 60 – 70 million Btu/yr** (≈ 17 000 – 20 000 kWh/yr equivalent) | **≈ 30 kBtu/hr** (≈ 9 kW) | Full-size 60 – 70 kBtu/h boiler or furnace; difficult to electrify without major panel upgrade. |

\*Space-heating **demand** (kBtu / ft²·yr) is the annual energy delivered to the living space, not the raw fuel input. Numbers reflect Brookline’s 5 800 HDD65 climate and modern ISO-NE grid carbon factor.

**Key take-aways**

1. **Passive House slashes heating energy ~ 75 %** versus a well-executed deep retrofit and ~ 85 % versus an unrestored historic home.
2. **Equipment size follows suit.** The Passive House’s peak load is so low that the smallest off-the-shelf cold-climate heat-pump both heats and cools it; a retrofit still needs 3–4 × more capacity.
3. **Carbon and operating cost**:
   * At today’s MA winter electric rate (~27 ¢/kWh) a Passive House spends **≈ $740/yr** on heat with a COP 3 heat-pump; the retrofitted home spends **≈ $2 700/yr**.
   * Using gas ($1.80/therm delivered) the pre-retrofit house spends **≈ $1 200/yr**, but its emissions are 5–6 t CO₂-e, versus **< 1 t** for the Passive House on the current grid.
4. **Retrofit still matters**: deep upgrades cut heating demand ~40 % and let most Brookline antiques electrify without doubling their service drop—but they will never reach the ultralow loads of new Passive construction because of geometry (complex façades, chimneys, basements) and airtightness limits (2 ACH50 vs ≤ 0.6 ACH50).

**Practical implications for Brookline policy**

* **Electrification cost curves** favor pushing new builds to Passive House levels—tiny loads mean very small (cheap) equipment and spare panel capacity.
* **Historic stock** dominates Brookline’s streetscape; incentives for wall insulation + window packages + blower-door verified air-sealing can still deliver two-thirds of the Passive House savings.
* **Building-code pathways**: keeping the Municipal Specialized Code for new construction and adopting an **Existing-Buildings deep-retrofit stretch appendix** would capture both sides of the gap.

## Appendix B - Heating-energy implications when you add density

| **Case** | **Envelope & standard** | **Floor area (ft²)** | **Households** | **Annual space-heating demand** | **Per-household change vs today** | **Why it shifts** |
| --- | --- | --- | --- | --- | --- | --- |
| **1 A. Gentle “up-and-over” retrofit** 2000 ft² historic SFH → *adds* 2 000 ft² top-floor and becomes a **4 000 ft² two-family**. Both stories get a deep-energy retrofit (dense-pack walls ≈ R-28, R-60 roof, new windows, blower-door ≈ 2 ACH₅₀) | Deep-energy retrofit | 4 000 | 2 | **≈ 75–85 MMBtu yr⁻¹** (22–25 000 kWh) | **-10 %** per household (≈ 38 MMBtu → 38–42 MMBtu) | One shared floor and a slightly tighter enclosure shave loads, but the bigger shell largely cancels the gain. |
| **1 B. Same two-family, but addition built to *Passive House* spec and existing shell fully reclad/air-sealed** (≤ 0.6 ACH₅₀, R-45 walls, triple-pane) | PHIUS 2021 | 4 000 | 2 | **≈ 20 MMBtu yr⁻¹** (≈ 5 800 kWh) | **-75 %** per household | Ultralow loads let one 9 000 Btu/h cold-climate mini-split heat an entire flat. |
| **2. “Missing-middle” replacement** **Five 2 000 ft² pre-war houses** (total 10 000 ft²) are demolished and the lots combined for a **25-unit Passive-House apartment** (1 000 ft² avg; 25 000 ft²) | PHIUS 2021 multifamily (heating EUI ≈ 3.5 kBtu/ft² yr) | 25 000 | 25 | **≈ 88 MMBtu yr⁻¹** (≈ 26 000 kWh) | **-95 %** vs each existing house\* | Shared walls/slabs cut envelope area > 60 %; internal gains and airtight core drive heating EUI far below even single-family Passive levels. |

\*The five existing pre-retrofit houses each use ≈ 60–70 MMBtu/yr for heat (EIA RECS Northeast baseline). Replacing them with 25 Passive units drops community heating demand from **≈ 325 MMBtu to 88 MMBtu**—a **73 % site-energy cut even while increasing households 5-fold**.

**Reading the numbers**

* **Density amplifies efficiency.** Moving from detached shells to stacked flats slashes heat-loss area per unit; that’s why the 25-unit Passive building needs barely more heat than the two-family above it.
* **Retrofit + addition helps, but new-build Passive crushes loads.** Deep-energy work can roughly halve a Brookline antique’s heating use, yet a brand-new Passive envelope still outperforms it by another factor of 3–4.
* **Equipment and grid impacts scale accordingly.**
  + **Two-family, deep retrofit:** peak load ≈ 15–18 kBtu/h—each flat still needs its own 1-ton heat-pump.
  + **Two-family, Passive:** whole building peak ≈ 8–10 kBtu/h—one minisplit per flat.
  + **25-unit Passive:** ~75 kBtu/h for the *entire* block; a small VRF rack or modular ground-loop can handle it, freeing panel capacity for EVs and cooking.
* **Carbon savings:** Using ISO-NE’s 2023 grid factor (0.287 kg CO₂/kWh), the 25-unit Passive block trims **≈ 70 t CO₂-e every year** relative to the five gas-heated originals, and the two-family Passive retrofit saves ≈ 15 t CO₂-e/yr versus leaving the single-family as-is.

**Data sources & methods**

* Passive-House heating EUI (single-family ≈ 5 kBtu/ft² yr, multifamily ≈ 3.5 kBtu/ft² yr) derived from PHIUS 2021 calculator and Boston disclosure data showing **20.8 kBtu/ft² total EUI** for recent PH projects.
* Average Northeast single-family space-heating use (66 MMBtu/household) from 2020 EIA RECS Table CE3.2. [eia.gov](https://www.eia.gov/consumption/residential/data/2020/c%26e/pdf/ce3.2.pdf)
* Retrofit intensity taken from MassCEC deep-energy case studies (35–45 MMBtu for 2 000 ft² homes).
* Conversions: 1 kWh = 3 412 Btu. Peak loads assume PHIUS heating-load limit  ≈ 2.5 Btu/ft² h for Climate 5A and 15 Btu/ft² h for tightened but non-Passive retrofits.

These order-of-magnitude figures let Brookline gauge the carbon punch of infill versus whole-block redevelopment when setting policy and incentives.

## Appendix C – Embodied Carbon References

**1. UK Net Zero Carbon Building Standard (UK NZCBS)**

**Overview:**  
Developed by a cross-industry collaboration including LETI, UKGBC, RIBA, and others, the UK NZCBS (Pilot Version, 2024) provides guidance on assessing whole-life carbon for both new builds and retrofits. It aims to align buildings with a 1.5°C carbon reduction pathway.

**Relevant Guidance:**  
The standard includes methodologies for comparing whole-life carbon emissions between retrofit and demolition/rebuild scenarios. It encourages evaluating embodied carbon (from materials, construction, and demolition) and operational carbon (from energy use) over a building’s lifecycle, typically 60 years. While it doesn’t explicitly prioritize one approach over the other, it provides carbon emission limits and tools to quantify which option—retrofit or rebuild—yields lower whole-life carbon emissions for a specific project. For example, it notes that retrofitting can reduce embodied carbon by retaining existing structures, but a rebuild might be justified if operational carbon savings over time outweigh the upfront embodied carbon cost.

**Implication:**  
The standard implicitly supports choosing the option with lower whole-life carbon emissions, provided other factors (e.g., structural integrity, cost, heritage) are considered.  
*Source:* [*https://www.leti.uk/uknzcbs*](https://www.leti.uk/uknzcbs)

**2. Greater London Authority (GLA) Whole-Life Carbon Assessments**

**Overview:**  
The GLA’s London Plan (2021) and associated guidance require Whole-Life Carbon Assessments (WLCAs) for major developments. These assessments are part of planning policies to evaluate carbon impacts of retrofit versus demolition/rebuild.

**Relevant Guidance:**  
The GLA emphasizes a “retrofit first” approach but acknowledges that demolition and rebuild may be justified if WLCAs demonstrate lower carbon emissions over the building’s lifecycle (typically 60 years). For instance, a WLCA might show that a new, ultra-low-energy building could have lower operational emissions that offset the higher upfront embodied carbon compared to a retrofit. The guidance requires developers to quantify emissions from construction, operation, and end-of-life phases to make an informed decision.

**Implication:**  
While retrofit is prioritized, the GLA allows demolition/rebuild if the WLCA shows it is more carbon-efficient over time, aligning with your requested framework of comparing emissions over a set period.  
*Sources:* [*https://www.savills.com/ReimaginingRetail/rebuild-or-retrofit-the-environmental-case/*](https://www.savills.com/ReimaginingRetail/rebuild-or-retrofit-the-environmental-case/)  
[*https://www.london.gov.uk/who-we-are/what-london-assembly-does/london-assembly-press-releases/carbon-footprint-retrofit-vs-rebuild*](https://www.london.gov.uk/who-we-are/what-london-assembly-does/london-assembly-press-releases/carbon-footprint-retrofit-vs-rebuild)

**3. LETI Climate Emergency Retrofit Guide and Embodied Carbon Primer**

**Overview:**  
LETI (London Energy Transformation Initiative) provides practical guidance for retrofitting existing buildings to achieve net zero, with a focus on whole-life carbon. Its *Climate Emergency Retrofit Guide* (2021) and *Embodied Carbon Primer* emphasize deep retrofits to achieve energy performance close to new-build standards.

**Relevant Guidance:**  
LETI notes that retrofitting typically results in lower embodied carbon (50–75% less than new builds) by reusing existing structures. However, it acknowledges that in cases where a building is structurally unsound or cannot achieve near-zero operational emissions through retrofit, a rebuild might be preferable if whole-life carbon emissions are lower over a specified period (e.g., 30–60 years). LETI’s guidance includes case studies and tools to model these scenarios.

**Implication:**  
LETI supports retrofitting as the default but allows for rebuilds when whole-life carbon analysis justifies it.  
*Sources:* [*https://www.architecture.com/*](https://www.architecture.com/)*...*  
[*https://aecom.com/without-limits/article/*](https://aecom.com/without-limits/article/)*...*

**4. RIBA 2030 Climate Challenge and Circular Economy Principles**

**Overview:**  
The Royal Institute of British Architects (RIBA) promotes a “Retrofit First” campaign and sets embodied and operational carbon targets through its 2030 Climate Challenge.

**Relevant Guidance:**  
RIBA’s framework encourages assessing whole-life carbon emissions to compare retrofit and rebuild options. Retrofitting is generally preferable due to lower embodied carbon (e.g., retaining structural elements like concrete frames reduces emissions by up to 50%). However, demolition/rebuild is allowed if a WLCA shows that a new building’s operational efficiency results in lower total emissions over a defined timeframe.

**Implication:**  
RIBA’s guidance supports WLCAs to determine the lower-carbon option over time.  
*Source:* [*https://aecom.com/without-limits/article/*](https://aecom.com/without-limits/article/)*...*

**5. Whole-Life Carbon Assessment (WLCA) as a Decision-Making Tool**

**Overview:**  
WLCAs, as promoted by UKGBC, LETI, and the GLA, are the standard for comparing retrofit and rebuild. These assessments calculate emissions across a building’s lifecycle, including:

* **Embodied Carbon:** Material extraction, manufacturing, construction, maintenance, demolition.
* **Operational Carbon:** Energy use during operation.

**Relevant Guidance:**  
A WLCA can quantify whether a rebuild’s lower operational emissions outweigh the higher upfront embodied carbon compared to a retrofit. For example, one study compared a new-build shopping center with a retrofit over 60 years, showing a 50% embodied carbon reduction via retrofit.

**Implication:**  
WLCAs provide a quantitative basis for choosing the lower-emissions option over time.  
*Sources:* [*https://www.savills.com/ReimaginingRetail/*](https://www.savills.com/ReimaginingRetail/)*...*  
[*https://www.weforum.org/stories/2024/02/*](https://www.weforum.org/stories/2024/02/)*...*

## Appendix D – Patty Correa Memo on New Construction

The following content is from a memo from Patty Correa 4-16-2025. Notes related to the memo:

* A1 is included above as “**Mandate on-site solar for mid-/large new buildings”**
* A2 is not included in the above for two reasons:
  + We should not be proposing anything that is not already definitively better for emissions, including embodied carbon. If we adhere to this approach, then reporting will not be required.
  + More work would be needed to include this content
* A3 is included as “**Amend Public-Benefit Zoning Incentives to Prioritize Sustainability”**
* A4 is included as “**Density bonuses for verified net-zero performance”**

**A.1. Rooftop Solar Bylaw.** This type of regulation requires the installation of rooftop solar as part of new development at its outset, with a longer-term goal of targeting major roof replacements. As to new development, the purpose is to leverage solar-ready requirements of stretch code in new development. See examples/illustrations below. Watertown was the first in 2018, based on data that most rooftop solar was being installed on residential and not solar buildings, and that developers declined to consider actual solar installation during site plan review with the City. Cambridge included this in its 2023 CARP under on-site energy expansion initiatives as a near-term objective (by 2025), with a mid-term (by 2028) objective of exploring and expanding solar ready requirements to existing buildings by applying the solar ready requirements to major roof replacements. Cambridge’s reasoning for adopting the requirements include improving the cost-effectiveness of electrification of buildings and transportation (on-site charging), improving resiliency when paired with battery storage, and as a vehicle supporting the 2023 CARP initiative on a carbon fund. Cambridge noted the possibility of increasing rents.

Brookline could consider whether such a measure could be used to try to incentivize the build out of solar capacity additional to the needs of the development to help subsidize other initiatives, or as a vehicle for offsets/deductions as part of a BERDO or other initiative.

EXAMPLES FROM OTHER COMMUNITIES:

[Watertown Ordinance ch. 155 [zoning], s. 8.01](https://ecode360.com/37103457#45960907), Solar Energy Systems (passed in 2018). Requires that most new development that are equal or greater than 10,000 square feet or containing 10 or more residential units shall include a solar system that is equal or greater than 50% of its roof area. If a solar installation is determined to be feasible, the plan must be approved by the DCDP before installation. Solar is also required to cover 90% of new parking garages. The ordinance was adopted in 2018.

Cambridge Zoning Ordinance Article 22.30, Green/Solar Roofs (apparently amended since the 2023 CARP to include rooftop solar in green roofs ordinance). Non-working link to the ordinance itself. From the [Cambridge website](https://www.cambridgema.gov/CDD/zoninganddevelopment/sustainabledevelopment/article22greenroofsrequirement#:~:text=Under%20the%20Green%20Roofs%20Requirement,22.30%20of%20the%20Zoning%20Ordinance).): Most new buildings or structures over 25,000 square feet must have a green roof and/or solar energy system. (See [Section 22.30 of the Zoning Ordinance](https://library.municode.com/ma/cambridge/codes/zoning_ordinance?nodeId=ZONING_ORDINANCE_ART22.000SUDEDE_22.30GRRO)). These systems are not included in the Gross Floor Area. Submit the operation and maintenance plan for the Green Roofs to the Department of Public Works (DPW) for approval before applying for a building permit for any building containing Green Roof area. Developers can apply for a special permit from the Planning Board to reduce the amount of green roof they are required to build. The project team must make a “unit contribution” to the Cambridge Affordable Housing Trust for every square foot of reduction that the Planning Board grants.

CURRENTLY UNANSWERED QUESTIONS RELEVANT TO PRIORITIZATION FRAMEWORK:

1. Brookline Town Counsel opinion on feasibility in terms of State building code preemption. Watertown and Cambridge seem to have included that there is not a preemption issue, perhaps in light of stretch code solar ready roof requirements.
2. Questions for Watertown and Cambridge:
   1. Process for review/approval.
   2. Amount of staff support provided by number of FTE’s.
   3. Other budget cost elements (software, etc.).
   4. Impact/anticipated impact in terms of number of developments/kwh.
   5. Get case studies (or at least an idea from staff) illustrating owner cost-financing used-payback period based on projects having undergone City review. E.g., from [Watertown’s CARP](https://portal.laserfiche.com/Portal/DocView.aspx?id=85925&repo=r-5ece5628) w. photo of panels on Arsenal Mall: The ~2,700 rooftop solar panels installed at Arsenal Yards represent the largest solar energy project in Watertown, to-date. As of 2018, Watertown’s zoning ordinance requires solar panels on new and substantially renovated buildings over 10,000 sq. ft. and parking garages.
   6. Estimated costs to owners/developers of compliance/completing approval process.
3. Questions for Town staff:
   1. Information about pipeline and specifics of new development projects of which the Town is aware (e.g., to assess roof potential and estimate energy use for the development).
   2. Does this seem like a policy that could be incorporated easily into existing project review procedures? Can staff estimate the FTEs/other resources that could be needed without further information from Watertown/Cambridge? In Lexington, Sustainability staff sits on the design review committee anyway.

PRIORITIZATION FRAMEWORK (to the extent information is currently available to assess):

Ease of Financing: Need further information per Question 2(f) above.

Ease of Implementation (staff): Need further information per Questions 2(a)-(c) above. However, based on current level of knowledge about Town staffing and processes, there seems to be a good chance that this type of bylaw implementation could be incorporated into existing Town processes and staffing. I would categorize this as **Additional Work.**

Ease of Implementation (end user): Need further information per Questions 2(e)-(f). I expect that given developer resources, likely rating is **Medium.**

Climate impact: Need further information from the Town per Question 3(a).

Financial return on investment: Need further information from other communities and the Town per Question 2.

Direct v. indirect impact: **Direct.**

Equity: **N/A** [since a commercial focus].

Public visibility/community support: **Medium.** Low visibility, but likely public support though mixed, with economic development concerns. In press reports about Watertown’s ordinance, NAIOP representatives were quoted contending that Watertown’s ordinance was preempted by State building code (which Watertown disputed in the reports).

**A.2. Embedded Carbon Initiatives.** Cambridge’s [2023 Net Zero Action Plan](https://www.cambridgema.gov/cdd/projects/climate/netzerotaskforce) (NZAP) notes that 10% of global emissions, with particular impact in the short term, although not accounted for in the GHG emissions inventory. It noted that focus only on operational carbon distorts the carbon impact of new construction. It noted a near term (1-2 years) objective to study the topic and have peer learning listening sessions with Boston and others. It has a mid-term (3-5 years) target of setting construction carbon intensity criteria and reduction standards from baseline, with data collection tracking impact. It has a long-term objective (5+ years) of criteria facilitating a 50% reduction. Perhaps the Town’s CARP could include general enough language on embedded carbon to follow steps neighboring communities and the State are taking, their feasibility and impact, and what actions the Town might consider taking.

At the 4/14/25 CAB meeting, local architect Deborah Rivers showed a chart from [Build 2050](https://www.build2050.ips.pt/) illustrating the decades embedded carbon can add to a new project well past 2050, from a project that satisfies 2050 climate goals in terms of operational carbon. Tina McCarthy, Preservation Planner, stated at the CAB meeting that she is on a DEP committee or working group on this topic. Perhaps she could be consulted for further information. As stated in B below, Cambridge is or will participate with Boston and others in a peer listening effort. Perhaps Cambridge could be contacted to learn more about this.

**A.2.a. Embedded Carbon Reporting Bylaw**.[[1]](#footnote-1) This type of regulation requires reporting of whole building lifecycle analyses of the estimated emissions generated by new developments. Ms. Rivers stated that lifecycle analysis are more easily conducted these days through software and for a “standard” building could cost the developer in the range of approximately $5-6,000. She may have time to speak with us further. Primary objectives are ostensibly to encourage the exercise by developers and to collect data to form the basis for future initiatives.[[2]](#footnote-2)

Examples from other communities:[[3]](#footnote-3)

[Cambridge Zoning Ordinance 22.25.1](https://library.municode.com/ma/cambridge/codes/zoning_ordinance/392575?nodeId=ZONING_ORDINANCE_ART22.000SUDEDE) (enacted in 2022, per Cambridge’s current CARP) requires submission of a whole building lifecycle analysis of the estimated emissions generated by a new proposed development that requires a special permit or new development evaluation under Zoning Article 19, as specified by the [Embodied Emissions Reporting Regulations](https://www.cambridgema.gov/CDD/zoninganddevelopment/sustainabledevelopment/article22greenbldgrequirements). The effort is supported by an “[Embodied Carbon Educational Toolkit](https://www.cambridgema.gov/CDD/zoninganddevelopment/sustainabledevelopment/article22greenbldgrequirements)”.

[Boston Zoning Ordinance Article 37-7](https://library.municode.com/ma/boston/codes/redevelopment_authority?nodeId=ART37GRBUNEZECA_S37-7PRNEZECA) (“Net Zero Zoning”, enacted in January 2025) requires projects subject to Article 80 review with a gross floor area of at least 50,000 sq to submit, prior to prior to issuance of a certificate of completion, “an embodied CO 2 e emissions life cycle assessment that considers the global warming potential from the raw material supply, transport, manufacturing, construction, use, and end-of-life of above and below grade structural and enclosure building product materials , and other construction-related activities such as the installation, replacement, and disposal of materials” by a licensed professional in design and engineering of buildings/systems.

CURRENTLY UNANSWERED QUESTIONS RELEVANT TO PRIORITIZATION FRAMEWORK:

* 1. Questions for Cambridge:
     1. Process for review/approval.
     2. Amount of staff support provided by number of FTE’s.
     3. Other budget cost elements (software, etc.).
     4. Estimated costs to owners/developers of compliance/completing approval process.
     5. Based on experience to date, how useful has the information been to developing other embodied carbon initiatives in Cambridge’s 2023 NZAP.
  2. Questions for Town staff:
     1. Does this seem like a policy that could be incorporated easily into existing project review procedures? Can staff estimate the FTEs/other resources that could be needed without further information from Watertown/Cambridge? In Lexington, Sustainability staff sits on the design review committee anyway.

PRIORITIZATION FRAMEWORK (to the extent information is currently available to assess):

Ease of Financing: Need further information per Question 2(f) above.

Ease of Implementation (staff): Need further information per Questions a.i.-iii. above. However, based on current level of knowledge about Town staffing and processes, there seems to be a good chance that this type of bylaw implementation could be incorporated into existing Town processes and staffing. I would categorize this as **Additional Work.**

Ease of Implementation (end user): Need further information per Question a.iv.. I expect that given developer resources, likely rating is **Medium** or **High**, depending on the project**.**

Climate impact: Need further information from the Town per Question a.v.

Financial return on investment: Need further information from Cambridge as above.

Direct v. indirect impact: **Indirect.**

Equity: **N/A** or **Medium**, depending on the cost to the developer and the type of development (e.g., expensive and project is for affordable housing?). Impact could be mitigated with design of reporting requirement.

Public visibility/community support: **Medium.** Low visibility, but likely public support though mixed, with economic development concerns.

**A.2.b. Adaptive Reuse.** Cambridge’s 2023 NZAP, pages 40-41, has near term (first 1-2 years) objectives of having developers consider reuse and report on that consideration in various respects, and to study and have listening and learning sessions with Boston and other communities. It has mid-term objectives of developing a policy to encourage developers to reuse They are in early stage development and not sufficiently developed and described online to consider them as potentially initiatives. More information could perhaps be obtained by contacting Cambridge, and by following Cambridge’s and the State’s efforts. In addition, Senior Planner Tina McCarthy sits on a DEP working group that studies embodied carbon and reuse and could perhaps be consulted. QUESTION: Could such policies (perhaps with feasibility studies and carbon lifecycle analyses be incorporated into future Town building project development when opportunities arise)?

**A.3. Review/Possible Amendment of Public Benefit Zoning Incentives.** Zoning By-Law Article 5.32 (increase in height by special permit) does not include sustainability at all among the list of public benefit incentives. While it is included in ZBL Article 5.21 (increase in FAR based on a list public benefit incentives, including sustainability) and the Planning Board’s Design Guidelines on Counterbalancing Amenities applicable to special permit applications, it is framed in general terms (“sustainability”). The Town has a Comprehensive Planning process underway. In connection with promoting sustainable new development, it may be considered whether incentivizing high priority items, for example, on-site renewable energy (solar, geothermal), could be explicitly included as recognized public benefits in zoning decision-making, especially now that the Town has adopted the municipal opt-in specialized code and is participating in the Fossil Fuel Free DOER project.

**A.4. Green Door Policies/Practices.** The Town could review and consider the desirability and feasibility of Green Door-type policies and practices that streamline/expedite project approval processes that meet the Town’s sustainability/decarbonization goals (which developers highly value, due to cost-savings they offer).

1. QUESTION: Could such policies be incorporated into future Town building project development when opportunities arise? [↑](#footnote-ref-1)
2. QUESTION: Could such policies be incorporated into future Town building project development when opportunities arise? [↑](#footnote-ref-2)
3. The 2024 climate law, 2024 Mass. Acts. ch. 239, section 4 (amending G.L. c. 7C, s. 73, establishes a Embodied Carbon Intergovernmental Coordinating Council to develop criteria for low carbon construction for State projects, conduct research, and develop policy and regulatory recommendations, including possible changes to the State building code. [↑](#footnote-ref-3)