FINAL REPORT

Cambridge Net Zero Action Plan

2021 Update

Date: December 16, 2021


DNV

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List of acronyms used in this report

BAU:	Business As Usual
BEUDO:	Building Energy Use Disclosure Ordinance
CO2:	Carbon Dioxide
CCA:	Community Choice Aggregation
CEA:	Cambridge Energy Alliance
CPAC:	Climate Protection Action Committee
GHG:	Greenhouse Gas
IPCC:	Intergovernmental Panel on Climate Change
MT:	Metric Tons
NZAP:	Net Zero Action Plan
UNEP:	United Nations Environmental Programme
ZNE:	Zero Net Emissions

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1 INTRODUCTION

The City of Cambridge shares increasing global concerns about the climate change crisis and the many challenges it presents. This crisis threatens the ability of the planet to support secure, healthy, productive, and enriching lives for current and future generations.

The climate imperative: Climate change poses a growing set of risks and challenges to cities.

In November 2014, when Cambridge was examining strategies for reducing greenhouse gas (GHG) emissions from the building sector, the United Nations (UNEP) issued its fifth Emission Gap report – an analysis of the gap in emissions reductions needed worldwide to limit global warming in this century to a 2°C increase. This was the level deemed necessary to avoid the worst impacts of global climate change. The report concluded that to stay within the 2°C limit, global carbon neutrality must be achieved between 2055 and 2070. The most recent Gap report found that, despite a decade of increased political and societal focus on climate change, emissions have not been curbed and the gap is larger than ever.[1] This current science calls for a 50% reduction in emissions vs. 2015 levels by 2030 and 100% reduction by 2050.[2]

In Cambridge, buildings are both part of the problem and part of the solution for addressing climate change. Over 80% of greenhouse gas emissions are from building construction and operations[3]. In our thriving economy, new buildings continue to be developed. Since the original NZAP was issued (2015), more than 8 million square feet of buildings have been added. If the City can get to net zero in the building sector, major progress toward achieving the U.N.'s goal of carbon neutrality in our city will have been made. This is why Cambridge aims to achieve net zero emissions from buildings by no later than 2050.

The current Net Zero Task Force wishes to underscore the urgency surrounding climate action. While the scientific GHG emission reduction targets listed above should be the starting point for Cambridge's activity, given the City's strong technical and financial resources and history of leadership by example, the Task Force recommends that Cambridge seek to exceed the current science-based targets to drive innovation that can help other communities follow suit at the pace needed to meet the global targets. To achieve even more aggressive action, the City should continue to monitor and pursue emerging opportunities and technologies to accelerate GHG emission reductions and adapt the Net Zero Action Plan appropriately on a regular basis. The stakeholders represented by Task Force members can help achieve this innovation through peer learning activities, and state and federal government should be engaged to advance the enabling policies and resources needed to achieve decarbonization of buildings at the local level. The Task Force also recommends centralizing GHG emission reductions as a priority across City administrative, decision-making and budgeting activities, including City Boards and Committees.

Net Zero Emissions are defined in the Net Zero Action Plan as a community of buildings for which annually all greenhouse gas emissions produced through building operations are offset by carbon-free energy.

1.1 Background

The City of Cambridge has long been steadfast in addressing climate change. In 2002, the City adopted the Climate Protection Action Plan. This was the first attempt at proposing emissions reduction targets and recommendations to reduce greenhouse gas emissions. At that time, a goal was set to reduce emissions 80% by 2050. Over the years the

[1] Christensen, J. and Olhoff, A. (2019). Lessons from a decade of emissions gap assessments. United Nations Environment Programme, Nairobi
[2] ibid
[3] City of Cambridge 2012 Community-wide GHG Emissions Inventory

City has committed to a range of initiatives to support sustainable lifestyles and move the community toward greater resilience to climate change. Some of the key initiatives undertaken over the years are listed in Table 1-1.

By 2013 there was growing concern in the community that any new development would make the goal of reducing greenhouse gas emissions harder unless new developments were built to be net zero greenhouse gas emissions. Out of this concern, a group of Cambridge residents filed a zoning petition (the Connolly Petition) requiring that all new buildings over 25,000 square feet either be net zero emissions or annual offsets would be required. The petition was met with considerable apprehension. The main objections were that the types of buildings constructed in Cambridge could not physically achieve a net zero performance on site and that the offset requirements would drastically increase development costs, and thereby drive business out of Cambridge and stifle the local economy. While the Connolly petition was met with concern, it was the catalyst in bringing the issue of greenhouse gas emissions from buildings to the forefront.

In response, the City convened the Getting to Net Zero Task Force to foster a deep conversation among stakeholders to advance the goal of setting Cambridge on a trajectory to becoming a "net zero community," with a focus on carbon emissions from building operations. To ensure a collaborative process, the City appointed representatives across sectors to study the technical aspects in greater detail and develop comprehensive, actionable long- and short-term recommendations.

The Net Zero Action Plan (NZAP) was adopted by the City Council in 2015 following an 18-month stakeholder process to identify a phased set of actions to reduce greenhouse gas emissions from new and existing buildings. That plan targeted a 70% reduction in City-wide building GHG emissions by 2040 to place the community on the pathway to net zero emissions by mid-century, consistent with the 2014 UNEP Emission Gap report.

As part of the 2015 NZAP, the Task Force proposed that the whole suite of actions be reviewed every five years. These reviews were intended to allow for the overall strategy to adjust based on changing economic, technology, and stakeholder needs. The review process was to be similar to the initial work of the Task Force in that it would be supported by staff and informed by a similar group of stakeholders. Driven by the principles laid out in the NZAP, the five-year review would revisit both the full set of actions and the timeline and make recommendations for adjustments to the Plan targets, actions, and tracking mechanisms moving forward. The resulting deliverables will serve as ongoing evaluation tools, justification for adjustments, and an implementation plan for the updated Net Zero Action Plan.

The review of the NZAP began in 2019 with an evaluation of the plan's impacts to date. The five-year review Task Force was selected early in 2020. It was made up of 25 members of the community who have expertise in related subject matter and who could help inform a robust and equitable plan update. This report captures the results of the Task Force and NZAP impact evaluation work and provides an adjusted set of actions to help the City achieve its net zero emissions goals.

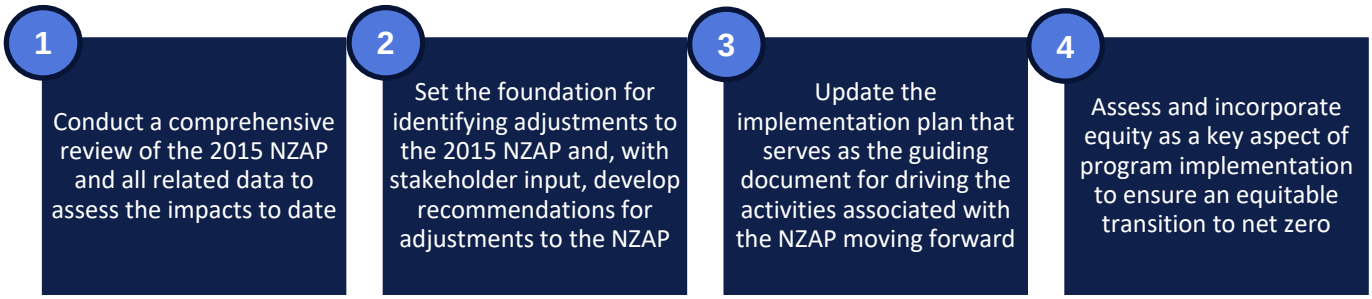
Table 1-1: Key Sustainability Initiatives Relating to the Net Zero Action Plan (2010-Present)

Year	Initiative
2010	Became a Green Community: The City was officially designated a "Green Community" by the Commonwealth of Massachusetts. As a designee, the City adopted the Stretch Energy Code, met the goal of reducing municipal energy consumption by 20% below an FY08 baseline and exceeded a goal of generating 5% of municipal electricity consumption by 2020 from on-site solar photovoltaic systems.

Year	Initiative
2010	Adopted Green Building Requirements as part of the zoning code in 2010 to promote environmentally sustainable and energy-efficient design and development practices in developments of 25,000 square feet or more, including new construction and some types of substantial renovation.
2014	Adopted the Building Energy Use Disclosure Ordinance in 2014: A foundational strategy that provides a means to provide building energy performance information to the marketplace and enhance local energy planning.
2015	Created and adopted the Net Zero Action Plan.
2011	Created the Cambridge Energy Alliance: A City-sponsored program aimed at providing technical assistance and helping Cambridge residents and businesses identify and arrange financing for energy efficiency and renewable energy projects.
2017	Completed a climate change vulnerability assessment that provided the technical foundation for a climate change preparedness plan, released in June 2021. A key focus of the plan was making buildings more resilient to precipitation, flooding, and extreme heat.
2017	Completed a community-wide GHG inventory using the baseline year of 2012.
2019	Amended the zoning to raise the new construction performance standard to LEED Gold for most buildings and require submission of a Net Zero Transition Narrative describing one or more pathways for transitioning buildings to net zero emissions in the future. Add increased setback flexibility for existing buildings seeking to install exterior insulation.
2021	Requirements for a technical and financial feasibility assessment for non-carbon based fuels and requirements for green roofs on new buildings were added to Article 22, Green Building Requirements. The Resilient Cambridge plan was published to address climate impacts throughout the community.

1.2 Purpose and goals of the five-year review

The update to the 2015 NZAP was a cooperative effort between the City, the consulting team, and the Net Zero Task Force. Driven by the principles laid out in the Net Zero Action Plan and with extensive stakeholder input, both the full set of actions and the timeline of the original plan were revisited. In addition, the process of reviewing and identifying adjustments to the plan considered the implications of actions with respect to equity and social justice; meaning the actions are to be implemented in a way that ensures resources are accessible to all residents and businesses and do not place undue burdens on vulnerable populations. In accordance with the governance plan, the study's purpose was to review the overall strategy to ensure that the framework continues to evolve in the desired manner. The objectives of this review were:



The results of this process are captured in this report, the 2021 NZAP Update. This includes justification for the adjustments made, an overview of the modeled emissions impacts and future trajectory, and an updated implementation plan timeline. Supporting documents and further details are provided in the appendices.

1.3 Organization of report

The rest of the report is organized as follows:

- **Section 2: Approach**
  This section summarizes the approach to determining the impacts of the NZAP over its first five years of implementation, the approach to assessing and incorporating equity aspects into the plan, and the process for working with the task force to identify recommended adjustments to the plan.

- **Section 3: GHG Emissions: Recent Trends and Impacts of Action To-date**
  This section covers the findings from the assessment of impacts of actions taken to date to implement the NZAP, and the GHG emission trend context for these actions.

- **Section 4: Recommended Actions**
  This section covers proposed adjustments to the NZAP and describes the expected impacts and key activities for each action going forward. The updated list of actions is as follows:

    - Action Area 1: Energy Efficiency in Existing Buildings
        - Action 1.1: Custom Retrofit Program for Residential (up to 50 units) and Small Commercial
        - Action 1.2: Emissions Reduction Requirements for Large Buildings (Building Energy Use Disclosure Ordinance amendments)
        - Action 1.3: Upgrades at Transaction Points
    - Action Area 2: Net Zero New Construction
        - Action 2.1: Net Zero Requirements for New Construction

    - Action 2.2: Address Embodied Carbon through Green Building Requirements
    - Action 2.3: Net Zero Requirements for Municipal Buildings
  - Action Area 3: Low Carbon Energy Supply
    - Action 3.1: Carbon Free Thermal Energy
    - Action 3.2: On-Site Renewable Electricity Access
    - Action 3.3: Off-Site Renewable Electricity Access
  - Action Area 4: Financing and Capacity Building
    - Action 4.1: Local Carbon Fund and Community Aggregation

- **Section 5: Estimated Impacts of Adjusted Actions**
  Section 5 looks at the anticipated impacts on future GHG emissions of the adjusted listed of Actions based on an updated model of the different actions and strategies.

- **Section 6: Recommendations for Operational Requirements and Implementation**
  This section describes the operational aspects and needs for implementing and monitoring activities going forward.

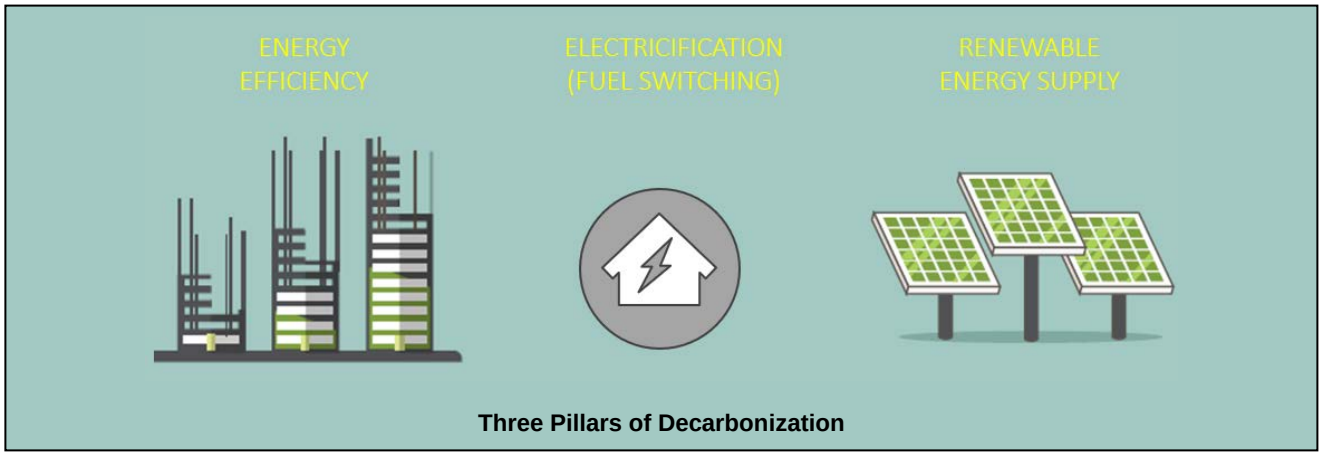
- **Appendices: Additional Information and Documentation**
  - Appendix A: NZAP Implementation Timeline
  - Appendix B: NZAP Impact Assessment
  - Appendix C: Program Tracking Metrics
  - Appendix D: Net Zero Task Force Feedback
  - Appendix E: Science, Policy, Technology, Equity Evaluation Framework
  - Appendix F: Methodology for GHG Emissions Inventory from Buildings
  - Appendix G: NZAP Impact Assessment Model Methodology
  - Appendix H: Net Zero Task Force Meeting Materials

2 APPROACH

The NZAP covers many different aspects of constructing, operating, and managing buildings. It is a complex plan that seeks to achieve significant levels of emissions reductions from assets that are traditionally energy- and emissions-intensive. In this plan we must consider how energy is used, where it comes from, and how it is distributed to commercial businesses and residences within the community. We must also consider the implications of such a plan on costs, people's livelihoods, and our economy. For this review, City staff worked closely with the consulting team to define a process that covered all the various touchpoints of the plan, incorporated extensive stakeholder feedback, and reflected upon how to implement the plan in an equitable way. This section presents a summary of the approach.

2.1 NZAP frameworks

There are three frameworks from which decisions about possible adjustments to the NZAP were made. The first is the original NZAP principles. The second is a Science, Technology, Policy, and Equity review. Third, a framework for assessing other benefits to the community beyond emissions reductions – co-benefits – was developed. In addition, the plan refers to the Three Pillars of Decarbonization. These are three key strategies to decarbonize energy systems that align with the United Nation's Sustainable Development Goals (SDGs) and include energy efficiency, switching end-uses of fossil fuels to electric-based equipment, and decarbonizing electricity (using renewable energy to produce electricity).



Three Pillars of Decarbonization

The set of ten principles that were developed during the 2015 NZAP process were intended to ensure that each time the plan was reviewed it would evolve in a manner aligned with the original intentions. These principles were updated prior to the 2021 NZAP review process to incorporate equity. With this latest addition, the driving principles for Actions included the NZAP are:

- Supports climate goals and healthy economic strategies
- Uses science, market, and data-driven analysis to inform decision making
- Supports an openness to new ideas when circumstances change
- Commits to allowing the principle of offsets
- Commits to measuring and monitoring impact over time
- Ensures consultation is comprehensive and engages affected stakeholders
- Commits to developing models that are replicable and informative to industry practitioners
- Commits to implementing the Net Zero Action Plan through a racial equity and social justice lens (NEW as of 2020)

Along with these ten principles, City staff and the consulting team worked with the Net Zero Task Force to consider adjustments to the NZAP Actions through a Science, Technology, Policy, and Equity lens (see **Appendix E** for details). That is, when considering adjustments:

- For Science: What do the latest scientific assessments say about emissions reductions needed? Current guidance is that they need to be reduced 50% below 2010 levels by 2030[4] and 100% by 2050 to stay below a 1.5-degree increase.
- For Technology: What enabling technologies have emerged since the 2015 NZAP efforts that may affect strategy?
- For Policy: What Federal, State, and Local Policies have changed that support these efforts to reach the goals (e.g., building energy codes)?
- For Equity: It is necessary to recognize the social equity implications of policy choices and use an equity assessment framework to help guide the process and ensure just outcomes (see Section 3.2).

In addition to the NZAP principles and the Science, Technology, Policy, and Equity lens, the team reviewed the potential co-benefits for each Action. This was a high-level qualitative assessment of what other benefits may be realized by adopting the Actions being considered. The co-benefits assessments covered six main categories as shown in Table 2-1, with Equity built into and spanning each. The co-benefits assessment was also used to determine priorities for action when the implementation timeline was created (see **Appendix A**).

Table 2-1: Co-benefits of Actions assessed as part of 2021 NZAP Update

Government and Policy Development	Economic	Environmental
• Leadership by Example	• Employment Growth	• Reduction in Water Use
• Promotes Collaboration	• Enhanced Economic Competitiveness	• Less Materials Use Impacts
• Facilitates Public Participation	• Reduction in Operation Costs	• Reduction in Waste
• Enhances Policy Evaluation	• Reduction in Cost of Public Infrastructure	• Lowers Air Pollution from Generation Assets
• Enhanced Data Availability and Access	• Decreased Energy Costs	• Lifecycle Carbon Emissions Reductions
Health and Wellbeing	**Climate Resilience**	**Access and Engagement**
• Promotes Healthy Lifestyle for Residents	• Increased Energy Security	• Improved Access to Public Space
• Lowers Combustible Gases in Buildings	• Provides Opportunity for Hardening Infrastructure	• Improved Access to Public Transit
• Improves Community Aesthetics	• Provides Opportunity for Improved Building Resilience	• Improved Access to Employment and Training
• Improved Building Comfort/IAQ	• Reduces Risk for Vulnerable Populations	• Engagement of Local Women/Minority Owned Businesses

[4] The NZAP Review process used 45% reduction by 2030 as this was the guidance at the time; however, most recent guidance indicates the need for a 50% reduction by 2030 (see https://www.ipcc.ch/sr15/chapter/spm/)

2.2 Equity and Net Zero Task Force Engagement Process

2.2.1 Equity and engagement process

A key element ensuring the continued forward-thinking of the Net Zero Action Plan is the plan's mandate that a detailed review of the whole suite of actions be conducted every five years. The 2021 NZAP update is the first such review conducted since the plan's adoption in 2015. The City of Cambridge is committed to implementing the Net Zero Action Plan through a racial equity and social justice lens. At the start of this work, Cambridge retained DNV, Sorensen Partners, and Applied Economics Clinic (AEC) as consultants to lead the City's stakeholder engagement process and to provide equity and justice input on the City's Net Zero Action Plan. That work began with assembling a broadly representative stakeholder Task Force. Throughout January and February 2020, the City – with support and guidance from AEC – invited participants to the Task Force to best represent the City's various stakeholders and vulnerable groups. The Task Force sought representatives from a variety of backgrounds, including:

- Community advocates and residents,
- University representatives,
- Planning board members,
- Business, finance, property owner, and developer representatives,
- Subject matter experts,
- Community equity and environmental justice organization representatives,
- Youth representatives,
- Utility representatives,
- Faith leaders,
- Affordable housing representatives, and
- Climate change advocates.

The final Net Zero Task Force included 25 members representing a range of technical expertise and community interests (see list above). Despite efforts to recruit a diverse set of participants, more work can be done to engage the broader community in the work of reducing GHG emissions from buildings.

The Net Zero Task Force held five remote full group meetings between November 2020 and June 2021. Two additional meetings were held in fall 2021 to review and provide feedback on the draft Net Zero Action Plan Update. Each meeting was two hours in duration, was open to the public, and included public comments in the last 10 minutes of the meeting. There were also six remote working group meetings to flesh out sector-specific strategies to recommend back to the full group. AEC provided equity guidance and input throughout the process as the Task Force worked to propose and evaluate adjustments to the Net Zero Action Plan. For summary of meeting content and outcomes and meeting slides, see **Appendix H.**

- **Meeting 1, November 2020 – NZAP Background and Introduction:** Presentation of Climate and Social Equity Framework and baseline equity considerations for the City of Cambridge.[5]
- **Meeting 2, December 2020 – Existing Data and Evaluation Approaches:** Guidance regarding the potential co-benefits of Net Zero Actions, including equity co-benefits.[6]

[5] https://www.cambridgema.gov/-/media/Files/CDD/Climate/NetZero/meeting1_cambridge_nzap_slides_final_111220.pdf.

[6] https://www.cambridgema.gov/-/media/Files/CDD/Climate/NetZero/Meeting2_Cambridge_NZAP_Slides_final.pdf.

- **Meeting 3, January 2021 – NZAP Strategy and Action Update Brainstorming:** Reponses to stakeholders' questions regarding equity.[7]
- **Working Group Meetings, February-March 2021 – Develop strategy and action update recommendations**
- **Meeting 4, April 2021 – Review Strategy and Action Update Recommendations and Equity Assessment:** Presentation on equity implications of the proposed Net Zero Action Plan adjustments, including equitable action design and implementation.[8]
- **Meeting 5, May 2021 – Review and Prioritize Updated Implementation Plan:** Presentation on the "equity rating" assigned to each proposed Net Zero Action – equity ratings indicate whether an Action, as it currently stands, is likely to have equity impacts that are positive, are neutral, or need to be addressed with additional action ("flagged").[9]

By treating science, policy, technology, and equity as consistent and equal foundational principles throughout the interactive planning process, the Task Force has assembled an implementation plan that represents a broad understanding of the challenges and opportunities faced by the City as it moves toward Net Zero buildings.

2.2.2 Equity summary

The actions included in the City of Cambridge's 2021 NZAP Update intend to reduce greenhouse gas emissions from Cambridge's buildings by improving design and operational efficiency and using renewable energy sources. In this report, each Net Zero Action has been evaluated and given an equity rating – positive, neutral, or flag – that is meant to reflect whether the Action, as currently written, is likely to entail more potential equity benefits, neutral equity impacts, or requires deliberate design to avoid equity pitfalls and maximize benefits, respectively. Net Zero Task Force members provided feedback on these ratings in Meeting 5.

Potential equity benefits include:

- Improved indoor comfort and air quality, which may be lower for vulnerable residents who struggle to pay energy bills to condition their homes and who may suffer from respiratory health conditions,
- Lower energy bills, which have the greatest positive impact on cost-burdened households (that is, housing and/or energy costs that account for more than 30 percent[10] of income),
- Increased access to financing and funding, particularly for those residents and businesses who lack upfront capital and strong credit for loans,
- Enhanced energy reliability, which is particularly important for residents with in-home medical equipment or other reliance on consistent power supply, and
- Increased resident engagement, awareness, and participation among all populations.

Potential equity pitfalls include:

- Housing, rental, and energy cost increases, which have the greatest negative impact on cost-burdened households,

[7] https://www.cambridgema.gov/-/media/Files/CDD/Climate/NetZero/meeting3_cambridge_nzap_slides_final_12121.pdf.

[8] https://www.cambridgema.gov/-/media/Files/CDD/Climate/NetZero/nzapmeeting4slides_41521_final.pdf.

[9] https://www.cambridgema.gov/-/media/Files/CDD/Climate/NetZero/nztfmeeting5slides52721.pdf.

[10] Spending more than 30 percent of household income on housing or energy costs is a standard definition of cost burdened. See, for example: https://www.jchs.harvard.edu/sites/default/files/Harvard_JCHS_State_of_the_Nations_Housing_2018.pdf.

- Inequitable program participation, and
- Inequitable distribution of benefits and burdens.

2.2.3 Equitable design and implementation

To advance potential equity benefits and mitigate against potential equity pitfalls, it is important that the City design its Net Zero Actions to specifically target equity by seeking to maximize the benefits and minimize the pitfalls described above. Once an action is implemented, the following steps should be taken to monitor its equity impact and make adjustments as needed:

- Tracking as many adjustment metrics as possible (e.g., housing and energy costs, program participation, improvements made, retrofits undertaken, pay-outs, renewable energy installations) to facilitate evaluation of the distribution of impacts on residents;
- Collecting disaggregated data that can shed light on the distribution of program impacts across Cambridge residents and businesses;
- Committing to reviewing program performance and providing public updates to facilitate transparency and accountability;
- Building in policy flexibility so that policies can be adjusted if inequitable outcomes arise;
- Providing updates that are easy to find and understand and available in multiple languages; and
- Engaging the community if a policy is adjusted– with representation from vulnerable residents – to provide guidance and feedback.

Not all the data needed to track the distribution of Net Zero Action Plan equity impacts as described above currently exists or is available to the City. Additional efforts would be required to access and create appropriate data and to measure progress toward equitable and just community impacts, with roles both for the City and stakeholders including utilities and building owners.

3 GHG EMISSIONS: RECENT TRENDS AND IMPACTS OF ACTIONS TO-DATE

To begin this process of updating the NZAP, DNV conducted an assessment of recent GHG emissions trends and the impacts of the actions taken over the first five years of the plan's implementation. This assessment provided both a top-down view of year-over-year building sector GHG emissions overall, and context from a bottom-up perspective where the impacts of different activities were measured. This section provides an overview of the building sector emissions and impacts of the NZAP on emissions since it was adopted five years ago.

3.1 Building sector GHG emissions profile

City staff have been tracking emissions through community-wide inventories as part of the commitment the City of Cambridge has made to achieving carbon neutrality by 2050. These inventories have provided a necessary foundation for enabling Cambridge to set emissions reductions targets and engage specific market sectors in actions to reduce emissions.

The most recent full community-wide inventory was completed in 2017 and covers emissions from buildings' energy use, transportation, solid waste, and wastewater management for the baseline year of 2012.[11] This inventory showed the building stock contributes nearly 80% of the greenhouse gas (GHG) emissions in the City, making it the key sector to address to meet the City's emissions reduction goals. As part of this review, the Buildings Sector inventory was updated for the years 2012 through 2019. Emissions by building and fuel types were analyzed to aid in the assessment of recent building-related emissions trends.

The updated inventory data provides a year-over-year emissions profile from building-related energy use in the City. The emissions calculations are based primarily on electric and gas consumption in the City but include fuel oil consumption and distribution systems losses as well. The consumption data were aggregated to broad industry sectors and building types within the City following standard methodologies for calculating emissions set forth in the Global Protocol for Community-scale GHG Inventories[12]. The detailed methodology is included as an **Appendix F**. Table 3-1 provides the emissions by year and sector for this time. Figure 3-1 provides a graphic charting these trends.

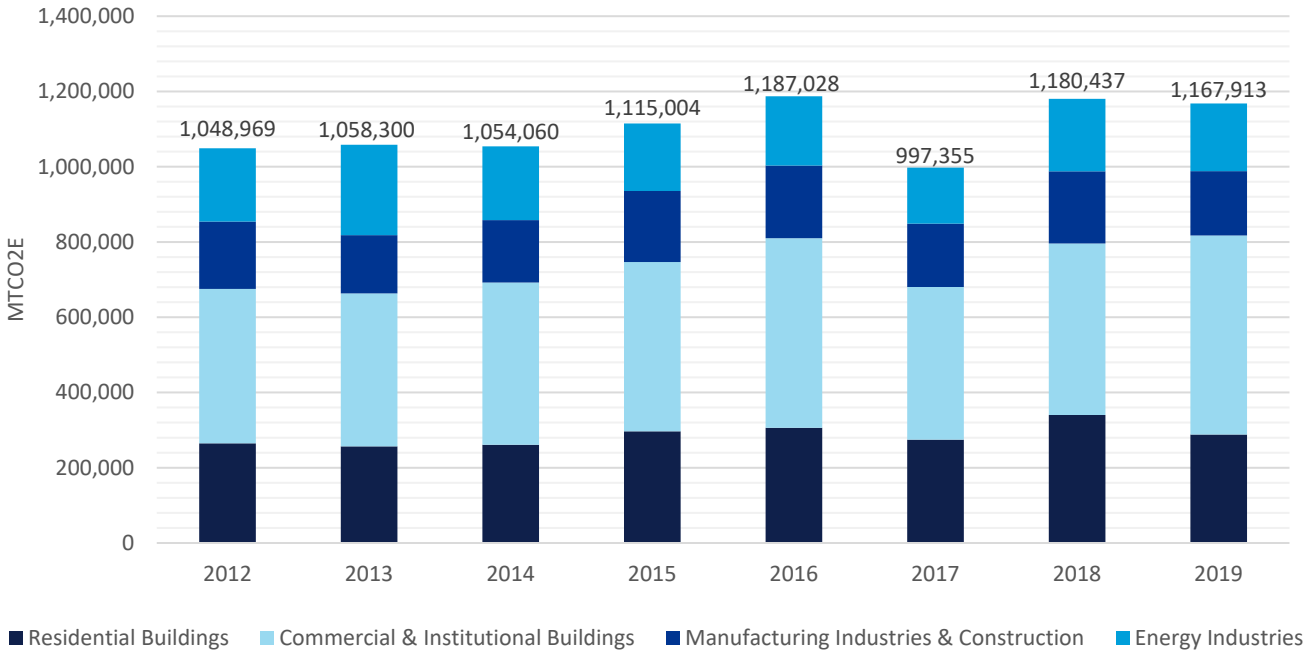
Table 3-1: Building Sector CO2e emissions 2012-2019

Subsector	2012	2013	2014	2015	2016	2017	2018	2019
Residential Buildings	264,858	256,990	260,914	296,864	306,138	274,685	340,365	288,407
Commercial & Institutional Buildings	410,178	406,281	431,384	449,793	503,852	405,847	455,569	528,953
Manufacturing Industries & Const.	179,026	154,629	165,798	188,702	192,945	168,036	191,990	170,870
Energy Industries	194,907	240,400	195,965	179,644	184,093	148,788	192,512	179,682
All Sectors & Subsectors	**1,048,969**	**1,058,300**	**1,054,060**	**1,115,004**	**1,187,028**	**997,355**	**1,180,437**	**1,167,913**

[11] Although the inventory was conducted in 2017, 2012 was the year of the emissions inventory because that was the most recent year with most comprehensive set of data available.

[12] See: https://ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities

Figure 3-1: Building sector emissions trends 2012-2019 (all building sectors)



The inventory data shows that although emissions fluctuate year to year, the general building sector emissions trend has increased slightly since 2012. There are many external factors that lead to fluctuations in emissions, including electric grid emissions factors, weather, and occupied floor area. DNV performed a regression analysis on the emissions data to better understand what may be driving the year-to-year changes. The analysis considered degree day data, policies enacted during this time, and commercial and residential floor area data and found that overall:

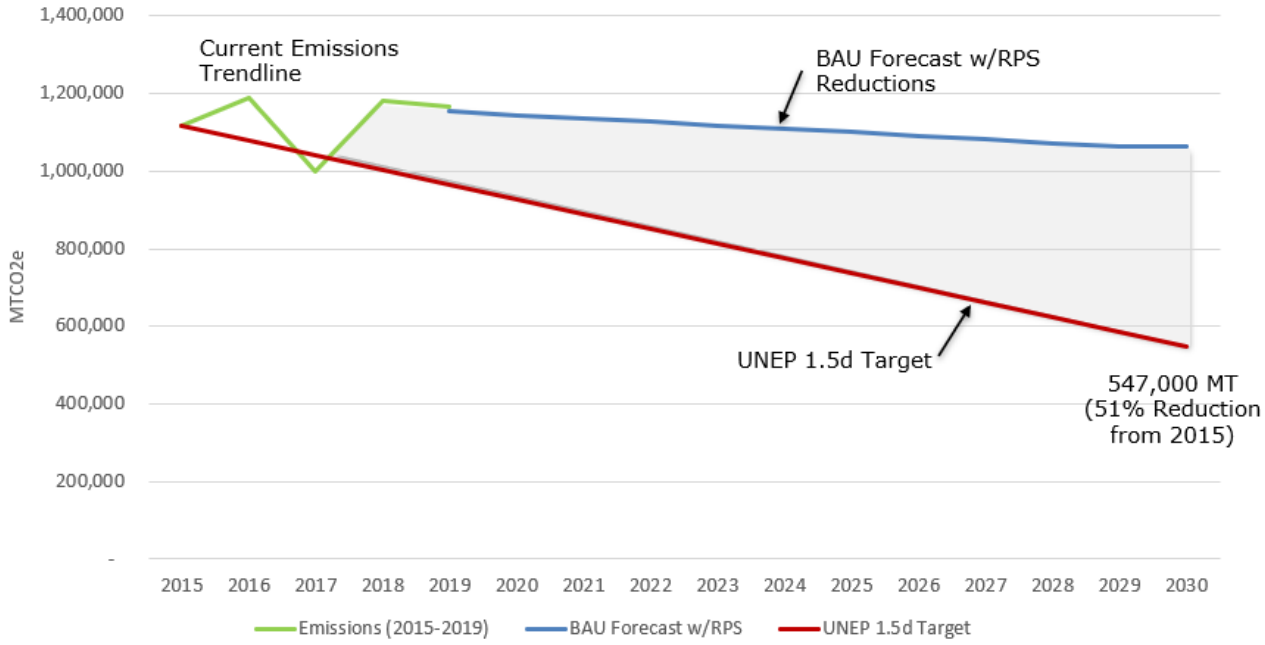
- The commercial sector has twice the impact on emissions trends as does the residential sector.
- More cooling degree days (an amount of time during the year when cooling is in demand in buildings) correlates with higher GHG emissions.
- Floor area added within the City from new construction projects was not statistically associated with changes in total emissions, as emission increases from new buildings were balanced out by increased efficiency and renewable electricity supply to the existing building stock.

While the primary drivers of emissions trends cannot be determined for certain, this analysis offers clues as to what has influenced emissions changes in recent years. Per the findings above, it should be expected that in the coming years as temperatures increase due to global warming that cooling demand will also increase. This will contribute to more emissions unless these systems are supplied with electricity from renewable resources. As for commercial buildings, addressing emissions from this sector will have a greater influence on the current trends than the residential sector. The current inventory does not take into account voluntary green power purchases, which could result in lower electricity sector emissions. Without emissions reductions from this segment, there will be little change in the emissions trajectory.

Figure 3-2 provides a comparison of the current trajectory versus the business as usual (BAU) projections and the 1.5°C UNEP target. The current trajectory is shown as the Recent Emissions Trendline in the chart below and was based on the emissions data from 2012-2019. The BAU forecast is the expected emissions forecast into the future from 2015 if no

intervention had taken place to curb emissions at the state or local level beyond the electricity emissions savings expected from the Renewable Portfolio Standard (RPS). This is based on historical population and jobs growth. What is clear is that if the current trends persist, the gap between actual emissions and the reductions needed to meet the UNEP targets will continue to increase, making it more and more difficult to achieve the City's goals for 2030 and beyond.

Figure 3-2: Comparison of current emissions trends and 2030 UNEP emissions target



Notes:
IPCC, 2018, Special Report on 1.5 degrees C, issued in 2019, indicated a decline of about 45% emissions from 2010 levels was needed to not overshoot a 1.5-degree increase. This chart references the latest UNEP Gap Assessment, indicating a 51% reduction is needed from a 2015 baseline.

The BAU w/RPS is reflective of the Massachusetts Senate Bill 9 signed into law in March, 2021 which increased the RPS to achieve 40% renewable energy by 2030

3.2 Impacts of NZAP to date

Along with the assessment of the year-over-year GHG emissions from the building sector, DNV conducted an assessment of the impacts of actions taken over the first five years of the implementation of the NZAP, whether part of the NZAP action plan or climate planning in general. A summary of the results is provided here. The full Impact Report is included as **Appendix B**. In this bottom-up assessment, each of the NZAP actions adopted in 2015 were reviewed and measurable impacts were quantified. DNV performed an in-depth review of the documentation related to each NZAP Action reviewing the underlying assumptions and anticipated emissions reduction impacts of the full set of NZAP actions. DNV reviewed all documents and data produced relating to the 2015 NZAP actions. These documents are listed in Table 3-2.

Table 3-2. List of documents reviewed

Document / Data	NZAP Action
FY16-FY19 NZAP Annual Progress Reports	Yes
Custom Retrofit Program (Action 1.1.1)	Yes
Article 22 Green Building Requirements (Action 2.3)	Yes
Renewal of Municipal Building (Action 2.4.2)	Yes
Rooftop Solar Ready Requirements (Action 3.2).	Yes
2014-2018 Building Energy Use Disclosure Ordinance (BEUDO) data (Action 1.1.2)	Yes
2017 Low Carbon Energy Supply Strategy (LCESS) model (Action 3.1)	Yes
Building Intervention Point Analysis (Action 1.1.3)	Yes
Market-based Incentives Program for New Construction (Action 2.2.1)	Yes
NZAP Model	Yes
2017 Community-wide GHG Emissions Inventory	No
Cambridge Community Electricity Aggregation Data	No
2018 Climate Action Plan Model	No
2019 Zero Cities Building Stock Analysis	No
Offsite Renewables Study Scope	No

Through this review, it was found that the primary focus over the first five years of the NZAP has been on confirming the feasibility of actions, designing the policies and programs from which the actions will be implemented, and getting the appropriate regulatory and reporting structure in place. Of the actions adopted in 2015, six were found to be beyond the feasibility and program design phase and were being implemented (i.e., the policy or program has been established and is being executed). Based on the review of the NZAP action-related documents, we noted the following:

- Four NZAP actions were determined likely to have had measurable impacts in the first five years of the program: Custom Retrofit Program (Action 1.1.1), Green Building Requirements (Action 2.3), Renewal of Municipal Building (Action 2.4.2), and Rooftop Solar Ready Requirements (Action 3.2).

- The Building Energy Use Disclosure Ordinance (BEUDO) enacted in 2014 is considered part of the NZAP, but emissions impacts will not exist until the performance improvement requirement is added.
- The Community Choice Aggregation program (CCA) was not an action originally adopted within the NZAP, but it is supportive of the Energy Supply action (NZAP Action 3).
- The City's renewable energy production goals are being met by multiple solar-related initiatives including Sunny Cambridge, Custom Retrofit Solar Advisor, and Rooftop Solar Ready, and are further influenced by the Article 22, Green Buildings Requirements.

The bottom-up review confirmed that significant efforts have been made to lay much of the groundwork for future success including policy planning, design, and regulatory action. Through the actions that are being implemented, there have been quantifiable emissions impacts, but the quantifiable impacts are not necessarily fully reflective of the efforts to date. Overall, the review and assessment of the NZAP actions found that:

- The 2015 NZAP has laid the groundwork to reduce emissions from the Cambridge building stock with quantifiable impacts from five strategies aimed at increasing the energy efficiency of buildings, improving the performance of new construction, and providing more renewables in the energy supply.
- Nearly 1,100 buildings in the City now report their energy and water usage to the City annually through the Building Energy Use Disclosure Ordinance (BEUDO), providing valuable information for planning and with future performance requirements currently being planned.
- Of the five NZAP Actions that were identified as contributing to measurable results to-date, improvements to data collection and program tracking are needed. The emissions savings could only be calculated for four of those actions based on availability of data, representing only 1% of the of the total buildings sector emissions in 2015.

There is a long lead time in obtaining project performance data for some of the NZAP actions, making it difficult to determine the real impacts of the program over the initial five-year period. To mitigate this, a recommendation was made to create a more robust system for reporting and tracking project-level performance data. While saving significant work, time, and money over having to collect performance data periodically, it will also provide the City more insight into the progress and performance of actions on an ongoing basis. Further, while it is expected the emissions trajectory will turn downward in the coming years as more impactful measures are taken, at both the state and local level, and more robust data management practices are implemented, the City needs to remain vigilant in its approach and find additional ways to cut emissions.

4 RECOMMENDED ACTIONS

This section presents a summary of the updated set of NZAP actions. Here each of the updated actions is presented with an overview of the action, its contribution to achieving the net zero emissions goals, a summary of the anticipated GHG emissions reductions from each action, the equity implications, and the key activities that need to occur to implement the action.

The adjustments to the 2015 NZAP actions were a result of a lengthy stakeholder engagement process as described above and a robust technical analysis of the possible impacts of the actions in the coming decades. These adjustments provide the City with a set of actions more focused on activities that the City has control over while also taking into consideration activities at the state level and by the local utilities (See Section 6.2). Table 4-1 provides a comparison of the original structure to the updated structure.

Table 4-1. Original NZAP Action structure vs. the 2021 updated structure

2015 NZAP	2021 NZAP Update
Action 1 Energy Efficiency	Action Area 1: Energy Efficiency in Existing Buildings
1.1.1 Custom Retrofit Program	Action 1.1 Custom Retrofit Program for Residential (up to 50 units) and Small Commercial
1.1.2 Additional BEUDO Requirements	Action 1.2 BEUDO Requirements
1.1.3 Upgrades at Time of Renovation	Action 1.2.1 Performance Requirements
1.1.4 Operation and Maintenance Plans for New Construction.	Action 1.2.2 BEUDO Resource Hub
Action 2 Net Zero New Construction	Action 1.3 Upgrades at Transaction Points
2.1 Net Zero New Construction	Action Area 2: Net Zero New Construction
2.2 Net Zero Incentives	Action 2.1 Net Zero Requirements for New Construction
2.2.1 Market-based Incentives	Action 2.2 Address Embodied Carbon through Green Building Requirements
2.2.2 Height and FAR Bonus	Action 2.3 Net Zero Requirements for Municipal Buildings
2.3 Increase Green Building Requirements	Action Area 3: Low Carbon Energy Supply
2.4 Net Zero New Construction for Municipal Buildings	Action 3.1 Carbon Free Thermal Energy
2.5 Removal of Barriers to Increased Insulation	Action 3.2 On-site Renewable Electricity Access
Action 3 Energy Supply	3.2.1 Rooftop Solar Requirement
3.1 Low Carbon Energy Supply	3.2.2 Community Solar Access
3.2 Rooftop Solar Ready Requirement	Action 3.3 Off-site Renewable Electricity Access
3.3 Develop a MOU with Local Utilities	Action Area 4: Financing and Capacity Building
Action 4 Investigate Local Carbon Fund	Action 4.1 Local Carbon Fund and Community Aggregation
Action 5 Engagement and Capacity Building	
5.1 Communications Strategy	
5.2 Develop Ongoing Capacity to Manage the NZAP	
5.3 Net Zero Lab Standards	

As may be seen from the table, some of the original actions have been removed. There were several reasons for removal of an action: the action having been substantially completed in the last five years; the action being integrated with another action because of its fit; or there not being enough return on the action to justify continuing to pursue it. The following are the actions that were removed from the NZAP:

- Action 1.1.4, Operations and Maintenance Plans for New Construction: This action is incorporated into the Green Building Requirements, which included a template for O&M plans.

- Action 2.2.1 Market Based Incentive Program: Removed due to revenue neutral policy constraints.
- Action 2.2.2, Height and FAR Bonus: This action was determined to require a significant legislative push for these incentives to be implemented, and that they would become obsolete when the net zero new construction standards are adopted in the coming years.
- Action 2.5, Removal of Barriers to Increased Insulation: This action was substantially completed when in 2019, the City adopted amendments to Article 22 that allow for increased flexibility in the installation of exterior insulation.
- Action 5.1, Communications Strategy: This strategy is on-going and was integrated with the NZAP Operation Requirements (Section 6).
- Action 5.2, Ongoing Capacity to Manage NZAP: Integrated with the NZAP Operation Requirements (Section 6).
- Action 5.3, Net Zero Lab Standards: This action was integrated with Action 2.1, Net Zero Requirements for New Construction.

In addition to the removal of some actions, Action 2.2 Green Building Requirements was substantially reworked to emphasize embodied emissions as net zero new construction standards (Action 2.1) are phased in to address operational emissions. Action 3.3, Off-Site Renewable Electricity Access, was re-worked to help address a need for assistance and guidance when businesses seek out options for purchasing grid-supplied electricity from renewable resources.

In creating this new structure, the overlap between the implementation of actions as well as the cross-cutting themes (issues that may be influenced by multiple actions) was taken into consideration. The cross-cutting themes were equity, energy resilience, the renewable thermal energy transition, electric transport, and local capacity. Each of these themes was heavily weighed when thinking through possible adjustments. The reason for continuously reflecting upon these issues was to create a set of actions that would enhance a fair and just clean energy transition, seek out opportunities to improve the energy resilience of the community while reducing reliance on fossil fuel-based energy, and ensure that a structure was in place and that resources would be available to implement this plan.

In reviewing the updated list of Actions, it is useful to keep in mind that some actions are “Enabling Actions,” while others have a direct impact on emissions. The Enabling Actions are those Actions designed to support the emissions reductions in another Action. Whether an Action is enabling or has direct impacts is noted in the Action descriptions, along with a brief description of the interplay between Actions.

This relationship between the Actions is emphasized in Figure 4-1 below. Here one can observe the organization of the Actions as they address existing buildings, new buildings, and energy supply through complementary approaches of requirements, incentives and technical support, and enabling actions. The success of the Net Zero Action Plan hinges on the interplay of these approaches, with requirements to drive action in buildings coupled with incentives, support, and enabling actions to facilitate the significant activity needed to achieve the NZAP goals across each sector. This framework strategy to decarbonizing buildings means that the Net Zero Action Plan should be taken as a whole versus relying on any single action or approach to reducing GHG emissions from buildings in Cambridge.

Figure 4-1: NZAP Action Map

The NZAP Actions should also be assessed in regard to City control and where there is reliance on regional and state actors to achieve the Action goals. In some cases, the City may be precluded from carrying out specific activities, such as providing direct financial support to private entities due to statutory limitations, which would therefore require outside action. Partnerships and advocacy should be established with the appropriate institutions to accomplish the activities of each Action. For example:

- Action 1.1: MassSave provides financial support and technical services for energy efficiency building and infrastructure improvements to Massachusetts residents and businesses. MassSave is governed by 3-Year Plans established by the Energy Efficiency Advisory Committee convened by the Department of Energy Resources and approved by the Department of Public Utilities.
- Action 2.1: The state building code regulates energy use in new construction and is established by the Board of Building Regulations and Standards, building off of the International Energy Conservation Code. The Act Creating a Next Generation Roadmap for Massachusetts adopted in March 2021 tasks the Department of Energy Resources to create a Net Zero Stretch Code for optional municipal adoption by late 2022.
- Action 3.2: The Department of Energy Resources regulates incentives such as the Solar Massachusetts Renewable Target based on the Renewable Portfolio Standard adopted by the state legislature.
- Action 3.3: The Renewable Portfolio Standard adopted by the state legislature governs the amount of renewable electricity that retail electricity suppliers must obtain and provide to their customers. The Act Creating a Next Generation Roadmap for Massachusetts authorizes additional offshore wind procurement to further increase the amount of renewable energy provided to the electricity grid.

4.1 Action Area 1 – Energy Efficiency

Energy efficiency is one of the three pillars of decarbonization, along with electrification and renewable energy supply. The energy transition cannot happen without the more efficient use of energy in buildings, especially when considering that energy demand will grow as the City continues to grow. In addition, coupled with another pillar of decarbonization, electrification, the need for more energy efficient electricity using equipment becomes more apparent. As end-users switch from equipment that combusts carbon-intensive fossil fuels on-site to equipment that uses a lower-carbon electricity supply, such as heat pumps and electric vehicles, demand for grid-supplied electricity will continue to grow.

Within the Energy Efficiency Action Area, this report focuses on three actions, each of which provide value beyond emissions reductions. They are:

- Action 1.1 – Custom Retrofit Program for Residential Buildings and Small Businesses
- Action 1.2 – BEUDO Emissions Reductions Requirements for Large Buildings
- Action 1.3 – Upgrades at Transaction Points

While BEUDO is expected to have the largest impact on emissions in the City overall, the Custom Retrofit plays a significant role in engaging residents and businesses (those not covered by the BEUDO requirements) in this effort. Further, when considering the economic potential of emissions reductions sources (energy efficiency, on-site renewable energy generation, and renewables purchased from sources outside the City – off-site renewables) the updated NZAP Model indicates that about 18% of the reductions needed to reach net zero by 2050 can be expected to come from energy efficiency related activities.

Action 1.1 – Custom Retrofit Program for Residential (up to 50 units) and Small Commercial

Overview

The intent of this Action is to ensure that small and medium residential and small commercial buildings are operating optimally and, where possible, are retrofitted to maximize energy efficiency. As part of this Action, the City of Cambridge develops and implements programs to help Cambridge residents and small businesses better access energy efficiency resources through outreach, technical assistance, and other support services. These programs are currently administered by the Cambridge Energy Alliance (CEA) in collaboration with Eversource and are designed to help residents connect with vendors, statewide incentives, and other resources for energy upgrades.

Over time, tools and policies may be directed broadly across building types, but to achieve the necessary emissions reduction in the near term, this Action will have three areas of focus:

- Multi-Family Custom Retrofit
- Low- and Moderate-Income Multi-Family Engagement
- Small Commercial Custom Retrofit

Interplay with other Actions:

Action 1.3 – Upgrade at Transaction Points
In the years to come, as the requirements for energy efficiency improvements at point of sale or time of renovation are adopted, the projects savings from the Custom Retrofit program will have greater overlap with the Action 1.3. To simplify accounting of savings, all savings will be attributed to Action 1.3 after 2025.

Action 4.1 – Local Carbon Fund and Community Aggregation
One of the main barriers to scaling energy efficiency improvements is access to financing. Action 4.1 would enable a greater amount of custom retrofit projects to be completed if that action is implemented.

As these programs continue to be implemented, the City will work with Eversource, the energy efficiency program administrators, and the Massachusetts Clean Energy Center to refine state-level incentive programs in ways that address the needs of the community. City staff will continue to monitor the uptake and participation in these programs by population segment and location and coordinate with Eversource on ways to adjust and achieve greater results.

Cross-Cutting Issues

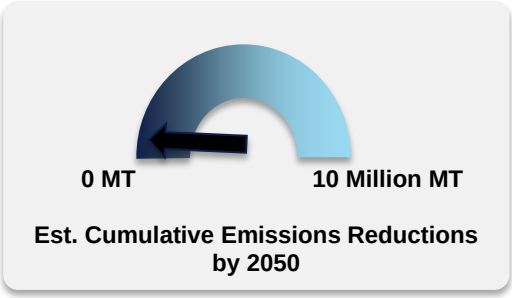
Renewable Thermal Systems	• Energy efficiency retrofits present an opportunity for replacement of fuel-based systems with electric systems
Climate Change Preparedness & Resilience	• In the design of these programs, consider incorporating resilience improvement assessments as part of any audit or energy efficiency improvement
Electric Transport	• To prepare for electric vehicles, programs should consider assessing access to charging stations and implications for buildings electrical equipment as part of any audit or energy efficiency improvement.
Capacity Building	• A local carbon fund could be designed to lower the cost of energy efficiency improvements for low and moderate income households and provide business owners greater access to capital.

Contribution to Net Zero Objective

The custom retrofit programs are instrumental for engaging residents and small business owners in the implementation of the NZAP. They align well with the principles of the NZAP, in particular: engaging affected stakeholders; developing informative and replicable models; and demonstrating commitment to equity and social justice. This Action has a number of other economic and social benefits, including potential for jobs creation, reduced building operational costs and improved comfort for building occupants.

This action has a Direct Impact on Building Emissions

Anticipated Level of GHG Reductions



Based on historical data showing participation in energy efficiency programs being between 3% and 6% of the annual electric use in the City, this Action is anticipated to achieve a limited amount of emissions reductions, especially as this program targets the residential and small commercial sectors (those with lowest energy use in the City). The larger contribution to emissions reductions will come later as energy improvements requirements at transaction points are initiated.

Equity

This Action aims to enable retrofitting of existing homes and businesses in Cambridge to achieve more efficient operations and energy savings. It has positive equity impacts because more energy efficient homes and businesses improve indoor comfort and air quality and lower energy bills. Vulnerable residents and businesses benefit most from such improvements, particularly those with increased risks from poor indoor air quality (such as residents with respiratory conditions or residents that are home-bound) and households and businesses experiencing energy burdens. This Action is unlikely to impact housing costs on its own, since it focuses on helping residents to access existing retrofit programs rather than changing the way those retrofit programs work.

Equity Rating:

Positive

Implementation and Key Activities

The key activities for implementation of this action are provided in Table 4-2. As the pilot retrofit programs are well underway now, it is important that as part of the NZAP the performance of the programs to-date be reflected upon and evaluated. From this the City will be able determine what adjustments should be made to the programs as they expand and attempt to engage harder to reach participants. As such, in the implementation of this Action, the initial steps are centered on completing this evaluation work. From there, opportunities will be sought out to expand program outreach and set the stage for success in the coming years.

Table 4-2. Key activities for implementation for Action 1.1 – Custom Retrofit Program for Residential and Small Commercial

Short Term Activities (1-2 Years)
1. Evaluate Pilot Programs As part of the roll-out of the retrofit pilots, an evaluation of the current programs will be completed, and the value of the technical support currently offered will be verified. Experience has shown that the target participants for the programs, including small businesses and multi-family properties, are often hard to reach. The evaluation will aim to identify strategies and adjustments that may be made to maximize participation.

2. Determine program adjustments

There are three aspects to this activity:

- Informed by the evaluation of the pilots, coordinate and align Retrofit Advisor services with MassSave program structures and delivery mechanisms.
- Identify a pathway building on current low and moderate income (LMI) and community assistance programs for more adequately engaging LMI households in retrofit activities (as a sub-sector of multi-family)
- Continue to establish the CEA as a resource hub for energy management information for homes and small businesses

3. Advocate for state energy efficiency program alignment

Since the City generally cannot provide direct funding to private entities, the state-level utility sponsored MassSave program is critical to providing financial assistance to building energy retrofit projects in Cambridge. The City should continue to advocate for MassSave program alignment with Cambridge's needs and goals through the Energy Efficiency Advisory Council three year planning process to deliver maximum support for Cambridge buildings.

4. Integrate Resilience and Electrification w/EE

The retrofit action presents an opportunity for improving resilience in homes and businesses as well as an opportunity to make electrification improvements. As part of this program, the City should seek to build in an electrification opportunities and resilience improvement assessment as part of any energy audit.

5. Identify means access to project financing

One of the key barriers preventing many homeowners and small businesses from completing energy upgrades as identified through the NZAP stakeholder workshop process is access to capital and financing. Therefore, it will be important to identify funding or financing vehicles that owners currently have access to, understand where there are gaps, and, if needed, create a support structure that links retrofit activities to capital. These investigative activities could become a basis for designing a local carbon fund/community aggregation program in later years. This activity will continue into the medium term

6. Increase transparency in program implementation

As a means to engage residents and businesses in taking a more active role in energy management, better energy data access and sharing needs to be available. As part of this activity, an appropriate energy data sharing platform should be identified and made available. This activity will continue into the medium term

Long Term (5+ Years)

7. Integrate with Enhanced Community Aggregation Program

As the City works to assess and develop a carbon fund and enhanced community energy aggregation programs (see Action 4.1), the retrofit programs too will evolve. The long-term vision for this action is to roll the financing and engagement activities into an enhanced community aggregation program.

Action 1.2 – BEUDO Requirements

Overview

The Building Energy Use Disclosure Ordinance (BEUDO) covers existing commercial buildings larger than 25,000 square feet and residential buildings of 50 or more units. While a small proportion of the total number of buildings in Cambridge, these largest buildings account for over 50% of the square footage and approximately 70% of the GHG emissions in Cambridge. By targeting these buildings for improvements, Cambridge will see significant progress in GHG emission reductions. This Action will have two tracks:

- Action 1.2.1 Performance Requirements – Requires all buildings subject to BEUDO to gradually reduce and achieve net zero emissions by 2050
- Action 1.2.2 BEUDO Resource Hub – Provides technical resources and guidance to support building owners in reducing GHG emissions

Interplay with other Actions:

Action 3.3 – Off-site Renewable Electricity Access

A key element beyond energy efficiency to BEUDO subject entities achieving their performance requirements will be access to renewable sources of electricity. At a certain point, the technical and economic feasibility of energy efficiency project becomes impractical, and therefore these entities will need access to emissions free electricity to reach the net zero targets.

Action 4.1 – Local Carbon Fund and Community Aggregation

Like Action 1.1, one of the main barriers to scaling energy efficiency improvements for commercial buildings is access to technical resources and financing. Action 4.1 is intended to enable a greater number of retrofit projects to be completed for BEUDO entities once that action is implemented.

Achieving the community-wide net zero target will require deep emission reductions from building operations. These two actions are intended to stimulate retrofit activities as well as clean energy generation and/or purchasing through a combination of capacity building, incentives, and regulation. At the core of this action is the existing Building Energy Use Disclosure Ordinance adopted in 2014,[13] which enables City staff and the public to monitor building energy and water use over time and ensure that emissions are moving toward the net zero objective. In addition, this data provides building owners an understanding of how their building's energy use compares to that of their peers and helps them determine where improvements can be made.

Under this action, technical support and information about state-level financial resources for building owners will be made available to help them achieve significant energy savings. This will build on the Building Energy Retrofit Program[14] currently administered by the City in partnership with Eversource as the state-level energy efficiency program administrator.

[13] https://www.cambridgema.gov/cdd/zoninganddevelopment/sustainablebldgs/buildingenergydisclosureordinance
[14] https://www.cambridgema.gov/Services/buildingretrofitprogram

Cross-Cutting Issues

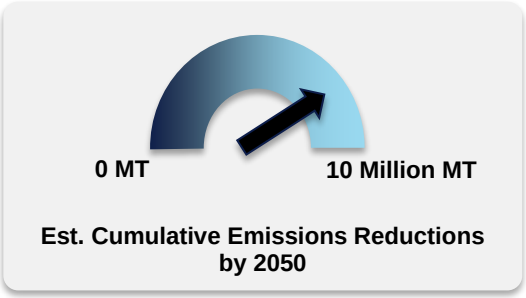
Renewable Thermal Systems	• To comply with BEUDO building performance standards, building owners will need to electrify thermal systems and decrease fossil fuel use
Climate Change Preparedness & Resilience	• Consider incorporating resilience improvement assessments as part of any building improvement project, including BUEDO
Electric Transport	• When energy improvements are being planned, BEUDO stakeholders should consider access to charging stations and implications for buildings electrical equipment
Capacity Building	• Additional access to financing and capital may increase the number of energy improvement projects completed, but the more valuable resource to BEUDO stakeholders may be peer-to-peer sharing of best practices

Action 1.2.1 BEUDO Performance Requirements

Contribution to Net Zero Objective

This action has a Direct Impact on Building Emissions

The BEUDO Performance Requirement is essential for meeting the City's net zero emissions goal. By adopting performance standards, owners (or real estate managers) of buildings that make up the largest source of emissions in the City will be required to find ways to reduce their emissions to net zero over time. The reductions will be realized through a combination of energy efficiency improvements and renewable generation and/or energy purchasing.



Anticipated Level of GHG Reductions

This action is anticipated to have the most significant impact on emissions reductions in the City through 2050 along with emission reductions from the state electricity grid.

Equity

Equity Rating:

Flag

Under this Action 1.2.1, Cambridge would require buildings to be compliant with GHG performance requirements. While this action places the greatest amount of responsibility on the largest emitters in the City to assist in the transition to a net zero emissions city, it must be noted that the costs of building upgrades may get passed on to tenants and—for multi-family buildings subject to BEUDO—increase housing costs, creating a potential equity pitfall. Increased housing costs would be most harmful to vulnerable residents and businesses – particularly those already experiencing housing cost burden. That said, housing costs in Cambridge are driven by a variety of market forces such as the balance of supply and demand, so the specific impact of energy upgrades is uncertain. The current BEUDO performance requirement proposal would give increased flexibility to affordable housing and allow affordable housing developers to access financial support to meet their upgrade requirements.

BEUDO requirements also entail potential equity benefits. Building upgrades will result in more energy efficient homes and businesses, which improve indoor comfort and air quality and lower energy bills. Such improvements are of the greatest benefit for vulnerable households and businesses, particularly those with increased risks from poor indoor air quality (such as residents with respiratory conditions or residents that are home-bound) and households and businesses experiencing energy burdens.

Implementation and Key Activities

The key activities for implementation of this sub-action are provided in the tables below.

Table 4-3. Key activities for implementation for Action 1.2.1 Performance Requirements

Short Term Activities (1-2 Years)
1. Enact Performance Requirements In the coming months, the performance requirements proposal will be finalized with stakeholder input and amendments will be submitted to City Council for adoption. The performance requirements will then be integrated into BEUDO administration guidelines and the program data platform.
2. Establish stakeholder advisory committee This activity may involve the establishment of a stakeholder advisory committee to oversee implementation and inform needed regulatory adjustments. As part of such an action, the City should consider merging the current Building Energy Retrofit Program advisory group with a future BEUDO advisory committee.
Medium Term Activities (3-5 Years)
3. Continue to implement and monitor energy performance Continue to monitor building performance, track and analyze data, and support performance compliance. Within five years, revisit performance requirements and adjust ordinance as appropriate.

Action 1.2.2 BEUDO Resource Hub

Contribution to Net Zero Objective

This action is considered an **Enabling Action**

The intention of the BEUDO Resource Hub is to arm building owners with the knowledge and the tools to identify areas of improvement, take action, and achieve net zero emissions in their own buildings. Key issues the resource hub should seek to address are electrification, fossil

fuel free district energy, and renewable energy procurement options, including solicitation, contracting, and pricing resources.

Anticipated Level of GHG Reductions

This action is considered enabling and is therefore not associated with GHG emissions reductions directly. The benefit of this action is that it enables building owners and managers to reduce emissions by providing useful information on how they may go about reducing emissions from the operations of their buildings.

Equity

Under Action 1.2.2, Cambridge will provide a Resource Hub for building owners to help reduce greenhouse gas emissions. In doing so, the action targets building owners only and there is no direct impact on Cambridge's vulnerable residents. That said, this action entails potential equity benefits in the same way BEUDO requirements do: building upgrades will result in more energy efficient homes and businesses, which is of the greatest benefit for the most vulnerable.

Equity Rating:

Neutral

Implementation and Key Activities

The key activities for implementation of this sub-action are provided below.

Action 1.2.2 BEUDO Resource Hub

Short Term Activities (1-2 Years)

1. **Expand a BEUDO resource hub**

Continue and expand Building Energy Retrofit Program and Resource Hub to support BEUDO buildings to achieve performance requirement goals, including assistance with energy efficiency, electrification, and renewable electricity. This may be in the form of an online resource center to connect professionals from the building industry with information and educational resources that provides advisory services similar to the Cambridge Energy Alliance program.

Medium Term Activities (3-5 Years)

2. **Evaluate Resource Hub Impacts**

The resource hub support activities will continue to be monitored, and within five years the program effectiveness will be evaluated and adjusted as necessary to meet BEUDO stakeholders' needs.

Long Term (5+ Years)

3. **Integrate with Enhanced Community Aggregation Program**

Over the longer term, this action could be integrated into an enhanced community aggregation program (see Action 4.1).

Action 1.3 – Upgrades at Transaction Points

Overview

Studies commissioned by Cambridge on this topic have projected that by 2050, all building area will be sold and/or touched by a renovation permit, with many being sold or renovated multiple times over that period. The intent of this Action is to ensure that transaction points in building life-cycles are leveraged to achieve energy improvements. Further, this Action is intended to deliver decarbonized buildings in a way that is financially feasible by tapping into financing streams that become available at transaction points. Transaction points may include time of sale, time of lease, and time of renovation/permit application. Transactions may also include time of replacement for heating and cooling systems, recognizing that there are few replacement opportunities for this equipment before 2050. A key challenge to address with this action will be the issue of condominiums which may have common HVAC systems, especially in older buildings.

Interplay with other Actions:

Action 1.1 – Custom Retrofit for Residential and Small Commercial

As the requirements for energy efficiency improvements from this action are adopted, there will be overlap with savings from the Custom Retrofit program. To simplify accounting of savings, all savings will be attributed to this action after 2025, the year this action is anticipated to be implemented.

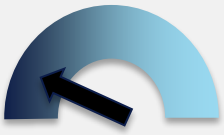
Cross-Cutting Issues

Renewable Thermal Systems	• This action should require that upgrades at time of renovation include the replacement of fuel-based systems with electric systems
Climate Change Preparedness & Resilience	• Consider incorporating resilience improvement assessments as part of any audit or Energy Efficiency improvement
Electric Transport	• Consider access to charging stations and implications for buildings' electrical equipment when upgrades are made
Capacity Building	• This action should be designed with a mechanism to offset losses incurred by landlords while units are unoccupied during the renovation period. Lost income can be a barrier to making improvements.

Contribution to Net Zero Objective

This Action is key to both increasing the energy efficiency of Cambridge's existing building stock and replacing fossil fuel-based equipment with renewable thermal systems.

This action has a Direct Impact on Building Emissions



0 MT **10 Million MT**

Est. Cumulative Emissions Reductions By 2050

Anticipated Level of GHG Reductions

The transaction points action is anticipated to be a key driver to emissions reduction from smaller existing buildings not covered by the BEUDO policy.

Equity

Equity Rating:

Flag

Under this Action, Cambridge would require building upgrades to enhance energy efficiency and replace fossil fuel-based equipment with renewable alternatives at the time of sale, lease, or renovation. A potential equity pitfall would occur if the costs of building retrofits at the point of transaction get passed on to the next building owner/tenant without a commensurate reduction in building operational costs, thereby increasing housing costs. At the same time, transaction points may provide access to financing, such as mortgages, which can make energy upgrades more accessible to building owners. Higher housing costs would be most harmful to vulnerable residents and businesses – particularly those already experiencing housing cost burdens.

Upgrades at the time of building transaction points also have the potential for equity benefits. Building upgrades will result in more energy efficient homes and businesses, which improve indoor comfort and air quality, and lower energy bills. Vulnerable residents, like those with increased risks from poor indoor air quality due to respiratory conditions or lack of mobility, would benefit most from more energy efficient homes.

Implementation and Key Actions

The key activities for implementation of this action are provided in Table 4-4. Short term, the focus will be on the design of this program and associated policies while also building up resources to help educate and inform building owners and contractors. The full policy is not anticipated to be implemented until 2024-2025.

Table 4-4. Key activities for implementation of Action 1.3 – Upgrades at Transaction Points

Short Term Activities (1-2 Years)
1. Program design The City has completed a study to explore a requirement for energy upgrades at transaction points (time of renovation permit or time of sale of property). Next steps involve: • Determining a means for tracking triggering events (i.e., what information does the City have that can be used to identify an intervention opportunity?) • Studying options for time of lease improvement requirements, considering affordability for tenants and revenue for landlords, especially in affordable housing • Determine whether time of sale upgrades are the responsibility of the buyer or seller and study financing options such as mortgages, home-improvement loans, and other means of building upgrade costs into existing and new transaction-point financing options • Identify a solution for addressing condominiums complexes with common HVAC systems

2. Develop toolkit / templates

Under the guidance of City staff, a toolkit should be created, including an electrification feasibility template/toolkit that can be used by owners/contractors to assess these types of opportunities at the time of transaction.

3. Implement contractor education program

While program design is underway, a contractor education program should be implemented. This is intended to utilize trade allies to drive progress and build capacity for this action.

Medium Term Activities (3-5 Years)

4. Establish resource hub

Building off the tools and educational activities undertaken in the short-term period, the City should seek to expand support services and provide technical and financial guidance to building owners to achieve upgrades. Though the City is unable statutorily to provide direct financing, the resource hub may be used to connect building owners with project financing assistance, including links to the enhanced community aggregation program described in Action 4.1.

5. Formally adopt upgrade requirements

Within the medium term, the City should assess and determine the appropriate upgrades and possible mechanisms for requirements at transaction points (sale, lease, renovation, replacement) based on short term lessons learned. Once these have been identified, the City should seek to formally adopt the requirements.

Long Term (5+ Years)

6. Implement, monitor performance, and adjust

Once the resource hub and requirements are fully established, it will be important to continuously monitor and assess the effects of the programs. See Section 6.2 for more information on program tracking. Adjustments to the transaction requirements should be made on a regular basis as appropriate.

4.2 Action Area 2 – New Construction

Cambridge has been a consistent leader on the issue of green design and sustainability in new construction. Fifteen years ago, there were no LEED certified buildings in Cambridge. Today there are more than 95, including 54 that were built or renovated in the last five years. As the green building industry has continued to mature, additional green building standards are being developed. At the state level, new legislation requires the development of a net zero building stretch energy code. This code change, once made available, can be adopted by the City and will supplant the need for local net zero requirements. In addition, embodied carbon in building design and construction has become an important issue for building professionals to address. By only focusing on emissions from the operation of buildings, the impacts of new construction may be substantially underrepresented. Material production for new buildings, including steel and concrete, are energy-intensive processes with their own emissions profiles, and there are strategies that can be used to curb emissions resulting from these processes that the City can control, such as encouraging adaptive re-use, which would lessen the need for producing new materials. The Actions for new construction have been adjusted to reflect these changing market conditions, and a new focus on embodied carbon has been added.

The timeline for the proposed Cambridge net zero new construction targets will follow the development and release of the Massachusetts net zero stretch code, which is expected to be available for adoption in 2022. The green building requirements will continue to exist to take advantage of the environmental and social benefits associated with green building practices, but will also be the key mechanism for addressing embodied carbon in new construction projects. The City should continue to show its leadership and create an environment of innovation through the municipal building net zero standards. All of these net zero targets for new construction projects should continue to be tracked and evaluated at regular intervals to measure the carbon impact of the actions.

4.2.1 Action 2.1 – Net Zero Requirements for New Construction

Overview

The initial targets developed for the NZAP shown in Table 4-5 are now considered outdated and require alignment with current standards practices, state-level code initiatives, and the urgency of addressing climate impacts from new construction activities. These original targets can be used as a reference point but should be adjusted as more information about the state net zero stretch code becomes available.

It is anticipated that the Commonwealth will take into consideration the feasibility and rate of market adoption of net zero design for different building types. Still, Cambridge will need to continue to be an advocate at the state level to ensure that state standards reflect local needs while aligning with net zero goals. Engagement with stakeholders involved in laboratory design will continue to be a key aspect to ensuring a successful rollout plan for net zero adoption. Any target dates for adopting sector-based NZE, whether set by code or not, will continuously be monitored and revisited as needed.

Interplay with other Actions:

Action 2.3 – Increase Green Building Requirements
As the requirements for net zero new construction are adopted, there will be overlap with savings from the Green Building Requirements. To simplify accounting of savings, all savings from non-municipal new construction projects will be attributed to this action after 2025.

Action 3.3 – Off-site Renewable Electricity Access
Because many new construction projects cannot achieve net zero status without the ability to purchase grid-supplied renewable energy, the criteria for purchasing that electricity defined in Action 3.3 will be used to achieve the goals of this action.

Cross-Cutting Issues

Renewable Thermal Systems	• Fossil fuel free new construction should be considered as part of net zero design
Climate Change Preparedness & Resilience	• Ensure that net zero aligns with resilient design strategies. Consider requiring a resilience narrative as a part of permit process
Electric Transport	• Charging station access or charging station ready design will continue to be pursued by the City for New Construction
Capacity Building	• For buildings unable to achieve net zero, a potential alternative would be contributions into a carbon fund for reinvestment in actions that reduce GHG emissions.

Contribution to Net Zero Objective

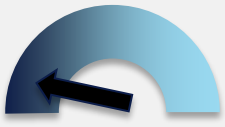
This action is anticipated to contribute to the net zero goals by avoiding emissions that would otherwise be added by new buildings. Recently a Small Residential Net Zero Feasibility Study was completed, showing that Cambridge is ready for net zero small residential new construction (and gut renovations) as there are no technical constraints, and there are multiple pathways to achieving NZE. The original NZAP targets for achieving net zero emissions by new building type need to be updated in alignment with the forthcoming state net zero stretch energy code.

This action has a Direct Impact on Building Emissions

Table 4-5: Original NZAP Timeline for Net Zero Construction by Building Type – *Update Required following state action*

Type:	Municipal	Residential	Multi-Family	Commercial	Institutional	Labs
Target Year:	2020	2022	2025	2025	2025	2030

Anticipated Level of GHG Reductions



0 MT **10 Million MT**

Est. Cumulative Emissions Reductions by 2050

Over the last five years, Cambridge has added an average of nearly 1.6 million square feet of new buildings per year. Considering growth projections, in the decades to come many more millions of square feet of floor could be added, which makes this action significant in changing the trajectory of annual CO_2 emissions. By implementing the net zero requirements for new construction, it is estimated the City will avoid over 100,000 MT of emissions annually by 2050.

Equity

Equity Rating:

Flag

Under this Action, Cambridge would adopt the forthcoming net zero stretch energy codes for all new buildings. Although recent experience shows that the cost of constructing net zero roughly aligns with the cost of traditional construction for many building types, in adopting the new code, the City must consider any incremental cost of net zero buildings – that is, costs above and beyond non-net zero buildings – that may be passed on in the form of increased housing or rental costs, creating a potential equity pitfall. The State is required to solicit significant public input, including specifically from underserved communities, in the stretch code development process.

Net zero buildings also entail potential equity benefits. Net zero buildings are more energy efficient, improve indoor comfort and air quality, and can lower building operational costs. Such improvements are of the greatest benefit for vulnerable households and businesses, particularly households with increased risks from poor indoor air quality and small businesses with narrow profit margins.

Implementation and Key Actions

The key activities for implementation of this action are provided in Table 4-6. Since this action depends on action at the state level, there will be a need for advocacy at the state level to ensure that proposed policies and implementation timelines align with the interests of Cambridge. In the meantime, the City should continue to explore and identify ways to fill the gaps left by state policies.

Table 4-6. Key activities for implementation of Action 2.1 – Net Zero Requirements for New Construction

Short Term Activities (1-2 Years)

1. **State-level advocacy**

State-level advocacy will continue with a focus on encouraging a state-level net zero code approach code and timelines that align with the City's interest in achieving net zero new construction within the timeline for each building type. In addition, the City should specify the energy efficiency and renewable energy standards being sought at the state level.

2. **Compile Net Zero Resources / Templates**

The City should begin to organize and compile resources for the architecture and engineering design community. Resources may include a tool kit and case studies meant to educate architecture and engineering community about the implications for building to net zero standards by construction type.

3. Adopt net zero stretch code

The City should position itself to be able to adopt the net zero stretch code at the earliest time possible.

4. Revisit and assess timeline for ZNE targets

Once the plans for the updated stretch code are better understood, it will be useful to assess the timeline of the ZNE targets to ensure the roll-out aligns with the City's goals. This activity should begin in the medium term and continue into the long term.

5. Eliminate pathways for fossil fuel use in new construction

New construction provides the best opportunity for full building electrification. In addition, the Massachusetts Decarbonization Roadmap has identified pathways for the drawdown of natural gas use; as a result, new construction must avoid becoming dependent on a shrinking gas system. To avoid these "lock in" challenges, the City will examine ways to eliminate fossil fuel-based systems in new or substantially renovated buildings, either through the use of the forthcoming stretch code or through other legal avenues

Medium Term Activities (3-5 Years)

6. Monitor performance

As the stretch code is adopted requiring all building typologies to achieve Net Zero New Construction, the City should continue to track and monitor the impacts of this action. This activity will continue into the long term.

Long Term Activities (5+ Years)

6. Monitor performance

As the stretch code is adopted requiring all building typologies to achieve Net Zero New Construction, the City should continue to track and monitor the impacts of this action and pursue adjustments as appropriate.

4.2.2 Action 2.2 – Address Embodied Carbon through Green Building Requirements

Overview

The Zoning Ordinance is a regulatory tool that Cambridge can use to incrementally require higher standards of green building and energy efficiency for large commercial projects. Large buildings, subject to Special Permit requirements, are currently required to design to a certain LEED or other similar green building standard. As a result, project developers are delivering buildings that are higher quality, are more resilient, and have less negative impact on the environment.

Interplay with other Actions:

Action 2.1 – Net Zero New Construction
As the net zero new construction requirements are adopted, the savings attributed to this action will transition to Action 2.1.

As we begin to transition to net zero codes, however, this action will also continue to evolve. While green buildings reduce energy consumption, they also provided opportunities for overlapping sustainability outcomes, including social equity, human health, and environmental stewardship. This action also provides the opportunity for the City to address another not previously considered but highly impactful source of carbon emissions: embodied carbon. Worldwide, construction materials are responsible for over 10% of global carbon dioxide emissions, with particular impact in the short term.[15] The purpose of this action will change over time from a focus on energy use to a focus on reducing GHG emissions from construction and choice of materials. These emissions will be targeted through the calculation and assessment of potential standards for managing embodied carbon in the construction and renovation of new and existing buildings.

Cross-Cutting Issues

Renewable Thermal Systems	• While green building design is still the focus, a focus will remain on all-electric design as part of the new construction standards
Climate Change Preparedness & Resilience	• Align green buildings requirements with recommendations from Climate Resilient Zoning Task Force
Electric Transport	• For green buildings, electric vehicle charging access in the design of new buildings will continue to be pursued
Capacity Building	• This action presents an opportunity for sharing information and educating the market on the issue of green building design and embodied carbon

*Note: The items described as the cross-cutting issues relate primarily to green building design. As embodied carbon becomes more of the focus, the cross-cutting issues to bear in mind will change.

Contribution to Net Zero Objective

This regulatory approach is a strong tool to demonstrate the City's commitment and leadership on sustainable new construction. Going forward, Net Zero projects should consider the impact of both embodied carbon and operational carbon. Including embodied carbon neutrality in the NZAP is an important step in the pathway to achieve a net zero carbon future. As embodied

New tools needed to determine impact on Building Emissions

[15] Cite

carbon is not included in the current Cambridge GHG inventory, until a framework is established for measuring embodied carbon emissions and accounting for reductions, the only impacts considered are from the existing Green Building Requirements.

Anticipated Level of GHG Reductions

The current Green Building Requirements are anticipated to result in emissions reduction over the next few years. However, when the Net Zero New Construction requirements are adopted, all operational emissions reductions associated with this action will be attributed to Action 2.1, while emissions impacts through addressing embodied carbon can be considered here.

Equity

Equity Rating:

Flag

Under this Action, Cambridge would continue its green building requirements for new construction and major renovations and seek to address the issue of embodied carbon within buildings. A potential equity pitfall would occur if the incremental costs of either the green building requirements or materials with lower embodied carbon content are passed on to tenants and increase housing or rental costs. Increased housing and rental costs would be most harmful to vulnerable residents and businesses – particularly those already experiencing housing costs that account for a large share of their income.

Greener commercial and residential buildings also entail potential equity benefits because more energy efficient buildings improve indoor comfort and air quality and lower building energy costs. Greener buildings also provide benefits beyond energy, including site sustainability, indoor environmental quality, non-toxic building materials, reductions in waste generation and water use, and increasing access to alternative transportation.

Implementation and Key Actions

The key activities for implementation of this action are provided in Table 4-7. With the adoption of the net zero stretch code, the emissions reductions from the action will transition to Action 2.1; however, this action will continue to be included as part of the NZAP, as it has many benefits to Cambridge and will seek to address the issue of embodied carbon as it evolves.

Table 4-7. Key activities for implementation of Action 2.3 – Address Embodied Carbon Through Green Building Requirements

Short Term Activities (1-2 Years)
1. Adopt embodied carbon narrative for new construction All new construction projects should be required to provide an embodied carbon narrative and adaptive reuse study for existing buildings for a limited set of the most impactful building materials for which emissions data is readily available. This is intended to inform the architectural and engineering community as well as developers of the embodied carbon issue and ensure that they consider adaptive reuse in their projects.
2. Assess LEED alternative pathways and zero carbon certification Because suitable alternative green design standards to LEED exist, the City should encourage the use of additional green building rating systems such as WELL and Living Building Challenge. In addition, the use of the Life Cycle Analysis LEED credit may be assessed to determine if that standard is helpful in addressing the issue of embodied carbon. The City should investigate the use of an embodied carbon certification requirement[16] for new construction projects and the practicality of implementing this type of certification program. This activity may be integrated with Action 2.1.
3. Design and develop policy to prioritize re-use

[16] See, for example, ILFI's Zero Carbon Certification: https://living-future.org/zero-carbon-certification/

Because re-use of existing structures in new construction projects is a key strategy for reducing embodied carbon, a policy that requires developers to prioritize the re-use of existing structures in their developments should be developed.

4. Design carbon intensity targets

Within this activity, appropriate Carbon Intensity targets for new construction projects will be assessed and designed as needed. These targets will give developers a goal to strive for in their projects.

5. Develop toolkit / templates

As part of this action, a series of educational materials and a toolkit for implementation of embodied carbon calculations should be developed to assist the development community in mitigating embodied carbon. Including protocols for assessing carbon intensity and documenting compliance.

6. Perform technical assessment of carbon impacts

To help inform the design of policies and programs, a technical assessment on the carbon impacts of using biogenic carbon materials will be performed.

7. Participate in peer learning sessions with other cities

Cambridge plans to participate in peer learning sessions with the City of Boston and others exploring the issue of embodied carbon.

Medium Term Activities (3-5 Years)

8. Adopt Life Cycle Analysis/carbon reduction requirements

In the medium term, a mechanism for requiring a whole building Life Cycle Analysis of the primary structural materials will be assessed, a baseline will be established, and the feasibility of having projects demonstrate a **20% reduction** of embodied carbon below that baseline will be determined.

9. Implement and monitor performance

As this program is implemented, the City should devise a plan for monitoring and periodically evaluating the impacts of the program.

Long Term (5+ Years)

10. Adopt enhanced Life Cycle Analysis/carbon reduction requirements

Over the longer term, it is anticipated that a Life Cycle Analysis requirement for the primary structural materials demonstrating a **50% reduction** of embodied carbon could be adopted.

4.2.3 Action 2.3 – Net Zero Requirements for Municipal Buildings

Overview

To demonstrate leadership, the City has for several years been designing and constructing new municipal buildings to be fossil fuel free and, since 2020, required to achieve net zero emissions. This also applies to "gut renovations" where a building is being completely renovated with new electrical, mechanical, interior, and envelope systems. For all other existing municipal buildings, greenhouse gas reductions have been a key priority throughout the municipal facilities improvement strategy, and the City has been working to integrate it with other priorities, such as life safety and accessibility. This commitment to the net zero and renewable thermal objectives will continue and provide a showcase for others for new technologies and how to achieve deep levels of savings through energy efficient design.

Interplay with other Actions:

Action 2.2 – Address Embodied Carbon through Green Building Requirements
As the City works to address the issue of embodied carbon within municipal buildings there will need to be coordination with the activities of Action 2.2.

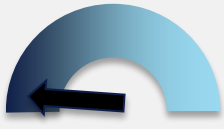
Cross-Cutting Issues

Renewable Thermal Systems	• All new municipal buildings should be designed to be fossil fuel free, which may include fossil fuel free district energy systems
Climate Change Preparedness & Resilience	• Municipal buildings should remain in operation and serve as a resource to the community during emergency events
Electric Transport	• The city may demonstrate leadership by installing EV charging station at municipal buildings
Capacity Building	• This action builds capacity through demonstrated leadership and piloting new technology

Contribution to Net Zero Objective

There is significant benefit to the City demonstrating leadership by committing to achieving fossil-fuel free construction and net zero emissions in its own building stock. This shows the City's commitment, demonstrates that net zero is achievable, will generate savings, and charts a path to net zero for private industry.

This action has a Direct Impact on Building Emissions



0 MT **10 Million MT**

Est. Cumulative Emissions Reductions by 2050

Anticipated Level of GHG Reductions

The greatest benefit of the Net Zero Requirements for Municipal Buildings is that this action demonstrates leadership and provides an example for others to follow.

Equity

Equity Rating:

Neutral

Under this Action, Cambridge would continue its policy that all municipal buildings be constructed to net zero standards. In doing so, the action targets municipal buildings only, and there is no direct impact on Cambridge's vulnerable residents. That said, this Action entails potential indirect and conditional equity benefits. Net Zero municipal buildings have benefits beyond energy, by promoting healthy indoor environments, the use of more environmentally friendly materials, and waste reduction. For example, if municipal buildings stop using energy generated from fossil fuels, then demand for fossil fuel energy declines, and vulnerable populations near polluting power plants benefit, as do residents and employees who spend time in municipal buildings – but the equity benefit is indirect and conditional on building performance.

Implementation and Key Activities

The short-, medium-, and long-term activities associated with this action are provided in Table 4-8. As it is, this action was successfully launched in the initial five years of the NZAP. It covers both the net zero requirement for newly constructed buildings and the renewal of existing public buildings. The activities here are intended to continue to expand and enhance the net zero strategy for municipal buildings, which include schools, administrative offices, and public libraries.

Table 4-8. Key activities for implementation of Action 2.4 - Net Zero Requirements for Municipal Buildings

Short Term Activities (1-2 Years)

1. **Net Zero Requirement for New Construction of Municipal Buildings**

New municipal buildings have been designed as fossil fuel-free and net zero emissions-ready in the past few years and this activity confirms that new construction of municipal buildings will continue to achieve net zero emissions and be fossil fuel-free.

2. **Renewal of Municipal Buildings**

This activity will continue implementation of (1) greenhouse gas reduction through energy efficiency, electrification and on-site solar as a priority when pursuing facility improvement projects of appropriate scale and (2) operational improvements. Within this activity the municipal building targets for retrofit and operational improvements will be defined.

3. **Municipal Building Embodied Carbon**

City of Cambridge should prioritize evaluation of embodied carbon for both new construction projects and in the renewal of municipal building and seek to develop methods to track and mitigate embodied carbon.

Medium Term Activities (3-5 Years)

4. **Renewal of Municipal Buildings (Cont.)**

Within this activity, the municipal building improvement strategy will continue to be implemented and piloting new technologies and emerging practices, and track improvements (GHG reductions) annually as well as implement strategies to reduce embodied carbon. Targets established in Activity 2 will be tracked.

Long Term (5+ Years)

5. **Enhanced Net Zero Requirement for New Construction of Municipal Buildings**

Over the longer-term, all new construction will be required to achieve net zero emissions both for operations and embodied carbon.

6. **Renewal of Municipal Buildings (Cont.)**

Continue to implement municipal building improvement strategy. This will align with the Municipal Facilities Improvement Plan. Renewable energy and GHG emissions targets work is currently underway to establish 2030 targets for municipal operations through the Municipal Facilities Improvement Plan, Clean Fleet project, and a Zero Waste Master Plan.

4.3 Action Area 3 – Energy Supply

Heating and cooling demand within the buildings in Cambridge is the largest source of emissions in the City. Addressing this issue will result in the largest emissions impact if electricity and natural gas supply is converted to a low carbon energy supply system. Achieving a low carbon energy supply, however, will be a significant challenge with complex parts to be addressed, many of which are not under the City's direct control. Many of the components needed to change the mix of energy supply require decisions and actions by utilities and state agencies and have effects across municipal boundaries.

Successfully decarbonizing the energy supply systems will require a combination of approaches over time. This section focuses on three main components: electrification of thermal systems; local (on-site) renewable energy supply; and procurement of renewable energy credits (RECs) from acceptable sources outside of the City (off-site renewable electricity). Electrification of buildings with grid-supplied electricity will play a central role in decarbonizing energy systems, as will the introduction of district energy systems in areas of high energy demand. While the actions in this section mainly focus on building-level strategies, district energy should remain as an option as it offers increased system efficiency, resilience, and flexibility of energy sources.

The Actions in this section cover all three aspects of transitioning to a low carbon energy supply system. Action 3.1, Carbon Free Energy Supply, covers electrification and the development of fossil fuel free energy systems such as air- and ground-source heat pumps. Action 3.2, On-site Renewable Electricity Access, seeks to cover the deployment of renewable electricity systems within the City of Cambridge, including on-site solar photovoltaics arrays and other distributed energy resources. Where there are emissions remaining from grid-supplied electricity that is not produced from renewable resources, there will need to be a means for procuring grid-suppled renewable electricity that complies with a city standard for RECs. This is the intention of Action 3.3 – Off-site Renewable Electricity Supply.

4.3.1 Action 3.1 – Carbon Free Energy Supply

Overview

Achieving net zero emissions and improving climate resiliency will require a significant shift from fossil fuel-based heating and hot water to low-carbon, renewable thermal systems. Specifically, this action will include continuing to support the electrification of individual buildings' heating and hot water systems, as well as enabling low-carbon district energy systems where suitable. In addition, the transition to renewable thermal will translate to changes in grid infrastructure and the gas network, and Cambridge should engage and lead on planning for an equitable, effective transition to renewable thermal energy supply.

Interplay with other Actions:

Action 1.3 – Upgrades at Transaction Points
The Transaction points action is intended to increase energy efficient retrofits in homes and small businesses; however, that action will also encourage electrification. There is likely to be some overlap between those electrification projects and emissions reductions achieved here through the Clean Heat program.

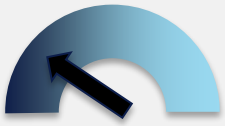
Cross-Cutting Issues

Renewable Thermal Systems	• This action would be supportive of and have direct influence over the expansion of renewable thermal systems in the city
Climate Change Preparedness & Resilience	• In addition to providing an opportunity to move equipment out of flood-prone basements, these systems provide needed cooling during times of extreme heat. On the flip side, electrified systems depend on a functioning grid.
Electric Transport	• With focus on renewable thermal energy, there is no influence on EV transport
Capacity Building	• Limited

Contribution to Net Zero Objective

About 49% of the emissions attributed to the building sector are from fossil fuel use. Accordingly, transitioning buildings to renewable thermal systems will be an important part of achieving progress on Cambridge's Net Zero goals. Electrification, using heat pumps and heat pump water heaters, enables buildings to eliminate fossil fuel use, instead using electric systems that can be powered by renewable electricity. District energy will continue to play an important role in commercial and institutional hubs, and potentially in other neighborhoods through the emerging 'geomicrodistrict' model. Existing district energy systems that are currently fossil-fuel based will need to transition to low-carbon sources of energy.

Enabling Action and has a direct impact on emissions



0 MT **10 Million MT**

Est. Cumulative Emissions Reductions by 2050

Anticipated Level of GHG Reductions

This action is considered both an enabling action and an action with direct emissions impacts. It is enabling in that low carbon energy supply supports emissions reductions for Action 1.2 BEUDO Requirements, Action 1.3 Transaction Points, Action 2.1 Net Zero New Construction as well as others. The Cambridge Clean Heat program and other efforts designed to help support the uptake of renewable thermal have direct emissions impacts.

Equity

Equity Rating:

Flag

Under this Action, Cambridge would encourage district energy systems in the City and promote renewable thermal energy systems. In doing so, the City must take into account that the cost of district energy and renewable thermal energy systems may get passed on to consumers in the form of increased energy costs, creating a potential equity pitfall. Increased energy costs would be of the greatest harm to the City's most vulnerable residents and small businesses. Inequitable uptake of renewable heating solutions – for example, if wealthy, homeowner residents are the program's primary beneficiaries rather than renters, low-income residents, or even condo owners who may have greater difficulty switching to renewable thermal systems, this is another potential equity pitfall. Should that happen – that is, primarily wealthy residents are converting away from fossil fuel heating sources – another equity pitfall is created whereby lower income utility customers are left behind and face increased fossil fuel heating costs because those costs are spread over fewer customers.

The City also has the potential to take advantage of positive equity impacts because district energy systems enhance localized, more reliable energy resources, which is of the greatest benefit to vulnerable households that face increased risks from heating interruptions – for example, households with young children, or infirm or elderly members. Removing fossil fuel combustion from inside of homes is also a key equity benefit by addressing a major source of indoor air pollution.

Implementation and Key Activities

The key activities for implementation of this action are provided below. This action seeks to find ways to scale up the adoption and installation of electrified heating and hot water systems, to enable the expansion of low-carbon district energy where appropriate, and to prepare the electrical grid and natural gas network for the transition to renewable thermal energy supply.

Table 4-9. Key activities for implementation of Action 3.1 – Carbon Free Energy Supply

Short Term Activities (1-2 Years)

1. **Continue to build the Cambridge Clean Heat Program and expand targeted outreach efforts**

The Cambridge Clean Heat program, which currently supports residents through technical guidance on heat pumps and solar hot water, should continue to grow. Expanded outreach to residents, including to likely adopters and through community groups, will help build program awareness. Targeted outreach to residents who are conducting other projects, such as air conditioner replacement, will connect people to the Cambridge Clean Heat program at useful engagement points. Finally, continued data collection through the program, such as information on existing conditions in buildings, will help inform program needs. The City should continue to implement and expand the clean heat program through strategic outreach to residents who have adopted other climate-friendly measures (e.g., electric vehicle owners), targeting buildings with planned AC replacement, and coordinating outreach with community partners and continuous improvement using the learnings from the CEA evaluation (2021).

2. **Expand support for multifamily building electrification**

The Cambridge Multifamily Retrofit Advisor should expand its work to support electrification, through preliminary feasibility assessments and recommendations for renewable thermal, additional educational resources, and identification of installers

3. **Engage with development teams and partner organizations on district energy**

To identify potential demonstration projects, City staff should seek to engage with project development teams to explore options for clean district or renewable thermal energy systems for new buildings. The City will continue to follow the developments of the shared geothermal model or “geomicrodistrict” – a study sponsored by Eversource to assess the feasibility of geothermal district systems. The geomicrodistrict approach would offer buildings the ability to access shared geothermal heating and cooling, with infrastructure installed and managed by the utility. The geomicrodistrict model may offer a pathway to high-efficiency electrification that is scalable, taps into load balancing opportunities across a neighborhood, and would create less demand on the grid than individual building electrification. The City will continue to engage the partners at the local, state, utility, and U.S. Department of Energy that are supporting this work and will examine the role it can play in new district energy systems in Cambridge. This activity will continue into the medium term.

4. **Engage the electric utility and building owners on deploying grid-interactive technologies**

City staff should continue to engage with the electric utility in conversations aimed at identifying and deploying flexible/grid-interactive technologies that can support electrification, including planning for grid capacity in context of distributed energy resources that could be adopted through an enhanced aggregation (Action 4). This activity will continue into the medium term.

5. **Identify possible demonstration projects for low-carbon microgrids**

Within the next 2 years, one of the outcomes should be the advancement of at least one microgrid demonstration project that supports building electrification.

6. **Lead engagement with utility and state partners to understand infrastructure needs to support decarbonization and the equity implications of these changes**

The transition to renewable thermal may require utilities to invest in the electric grid, as well a drawdown of the gas system. The City will proactively engage utility and state partners to understand these infrastructure needs and ensure that investments in Cambridge support decarbonization. In addition, the City should study and advocate for an equitable transition, especially as the economics of the gas system are expected to change. This activity will continue into the medium term

Medium Term Activities (3-5 Years)

7. Create a program to facilitate local district energy connections

The City should utilize the outcomes of Activity 3 to help facilitate the coordination of district energy where suitable. This may include 'matchmaking' between buildings whose thermal loads are appropriate for load balancing and could take the form of a geomicrodistrict, deployed in target districts.

8. Examine ways to ensure the uptake of low-carbon district energy by new buildings where feasible

The City should continue to examine ways in which new buildings could be encouraged or required to connect to low-carbon district energy systems if the site is served by such a system

9. Workforce Development

In partnership with state and regional organizations, enhance workforce development programs or partnerships to expand the pipeline of new workers in this growing yet labor-constrained industry.

10. Engage building owners in expanding building to grid or grid interactive tech

City staff should continue to encourage the use of grid-interactive technologies including virtual microgrids that can support the use of renewable energy, peak demand reduction, and electrification

11. Ensure inclusion of renewable thermal in any rental or transaction-point renovation standard

As the City explores options for a rental unit energy efficiency standard or transaction-point standard, the inclusion of renewable thermal will be important to avoid the lock-in of new fossil fuel-based systems

Long Term (5+ Years)

12. Integrate programs within Enhanced Community Choice Aggregation that provide new mechanisms for renewable thermal deployment

The City should examine the feasibility of using the enhanced Aggregation program to create new mechanisms that can help residents and business transition to renewable thermal (see Action 4.1). This could include equipment leasing or energy service models, or the facilitation of local microgrids.

13. Work with district energy system operators and legacy utilities to plan for a transition to decarbonized systems

In partnership with state and regional organizations, the City should engage district energy system operators and existing investor-owned utilities in Cambridge to explore equitable and resilient pathways to fossil fuel-free systems.

4.3.2 Action 3.2 – On-Site Renewable Electricity Access

Overview

On-site renewable energy access is intended to promote on-site renewable energy systems and provide support to building owners who may install these types of systems. This may include rooftop photovoltaics (PV), solar thermal, battery storage or fuel cells – systems capable of supplying renewable electricity to the host building. This action will have two tracks:

3.2.1 Rooftop Solar Requirements

3.2.2 Community Solar Access

For Action 3.2.1 – Rooftop Solar Requirement, Cambridge will continue to pursue a requirement for onsite renewable energy generation for new buildings, with a focus on solar. For roofs on new construction projects with available area, especially those where the potential to generate significant amounts of solar energy relative to building energy consumption, policies should aim to include solar PV and/or thermal. The purpose of this requirement is to ensure that suitable new buildings and, in the future, existing buildings have access to on-site solar generation or could easily be retrofitted at a later date where feasible.

For Action 3.2.2 – Community Solar Access; building off the solar initiatives undertaken to date, Cambridge should pursue implementing a third-party administered on-site community solar initiative. The primary aim of this program will be to enable the installation of solar on underutilized existing roofs and to give more residents access to the economic and resilience aspects of solar electricity. The program should be designed to overcome current roadblocks in deploying rooftop solar including: lack of building owners' upfront capital, challenges with building owners receiving technical and financial decision-making information, and owner/tenant split incentive challenges. This program will be designed to facilitate further development of solar and other distributed energy resources on-site. While reducing emissions at the state level, the program is also intended to promote resilience and enable access to solar for community members where there would otherwise exist ownership and economic barriers.

Cross-Cutting Issues

Renewable Thermal Systems	• On-site renewables are shown to improve the cost-effectiveness of renewable thermal equipment replacement options as well as increase the resilience of buildings
Climate Change Preparedness & Resilience	• This actions enables greater access to on-site backup power supply for when the larger grid is down
Electric Transport	• On-site renewables may serve as a source of energy for charging electric vehicles
Capacity Building	• Future carbon fund resources may be available to offset the costs of solar installations

Action 3.2.1 Rooftop Solar Requirements

Contribution to Net Zero Objective

The purpose of this requirement is to ensure that new buildings Include on-site solar generation to the extent feasible.

Anticipated Level of GHG Reductions

While the installation of renewable electricity systems such as rooftop photovoltaic (PV) panels produces emissions-free electricity, emissions reductions from such projects are not included as contributing to the goals of the NZAP, as the RECs from these systems are likely to be traded and counted as emissions reductions elsewhere.

Equity

In Action 3.2.1, Cambridge would pursue a requirement that new buildings with significant available rooftop area have onsite solar energy systems. In doing so, the City must take into account that the costs of rooftop solar energy sources could get passed on in the form of increased housing costs, creating a potential equity pitfall.

Equity Rating:

Flag

Renewable electricity produced on-site also entails potential equity benefits. The operational costs of solar electricity are very low and can result in energy cost savings for vulnerable Cambridge residents, depending on the ultimate distribution of program costs and benefits. When paired with energy storage, rooftop solar is also more reliable and resilient than electricity from the grid, which is of the greatest benefit for households that face increased risks from power outages, like those that require refrigerated medicines or rely on oxygen machines or nebulizers. An indirect equity benefit of increased on-site renewable energy is that it serves to increase the total share of electric demand being met with renewables and decrease the need for existing or new fossil fuel resources. The communities that shoulder the greatest burden of fossil fuel resources – and therefore stand to benefit the most from greater amounts of renewable energy – are vulnerable communities beyond Cambridge's borders.

Implementation and Key Actions

The key activities for implementation of this Action are provided in the tables below. For this Action, the mandate moves from requiring new roofs to be "solar ready" to requiring installation of e rooftop solar systems. One item that needs to be coordinated to implement this Action is the recently adopted requirement for green roofs.

Table 4-10. Key activities for implementation of Action 3.2.1 – Rooftop Solar Requirement

Short Term Activities (1-2 Years)
1. Integrate Solar Requirement with Green Roof Requirement for New Construction One possible conflict with a solar requirement for new roofs is the recently adopted green roof requirement. Before adopting a solar requirement, the City should study the potential to integrate a Solar Requirement for New Buildings with Green Roof requirements in collaboration with universities. If on-site solar is not required through the state net zero stretch code (see Action 2.1), a policy should then be developed for appropriate new buildings to be required to have solar panels installed. These may be either or both photovoltaic and solar thermal.
Medium Term Activities (3-5 Years)
2. Adopt a Solar Rooftop Requirement for New Construction Implement the new construction solar requirement based on the above activity as appropriate.
3. Investigate Solar Requirement for Major Roof Replacements Within the next five years, the City should seek to explore and expand the solar ready requirement to existing buildings by applying the requirements for solar ready to major roof replacements. This may include a study of the feasibility and

financial implications of a solar energy generation requirement for existing buildings, e.g. 5-10% of a given building's energy load.

Long Term (5+ Years)
4. Solar Requirement for Existing Buildings Longer term, the City should explore expanding the solar requirement further to cover existing roofs based on detailed feasibility studies. To accomplish this activity, an appropriate policy lever may be needed to increase on-site renewable generation requirements on existing buildings.

Action 3.2.2 Community Solar Access

Contribution to Net Zero Objective

The purpose of this action is to add solar photovoltaics to existing buildings and connecting consumers who cannot add solar themselves to the financial benefits of community solar.

Anticipated Level of GHG Reductions

While the installation of community solar projects produces emissions-free electricity, emissions reductions from such projects are not considered to be contributing to the emissions reductions goals because the State's SMART incentives for community solar automatically sell the solar systems RECs to the utilities to meet the State's Renewable Portfolio Standard. With the exception of municipal solar projects, most if not all private solar projects, participate in SMART[17].

Equity

Equity Rating:

Positive

Under Action 3.2.2, Cambridge would give more residents the ability to access the financial benefits of low-cost solar electricity by implementing an initiative to enable the installation of community solar systems on existing buildings. The City has the potential to take advantage of positive equity impacts because community solar programs reduce energy costs for participants. Community solar programs allow multiple customers to select the portion of the solar panels they own, and the customer receives a bill credit for the energy generated by their share. Vulnerable residents and businesses benefit most from lower energy costs, particularly those experiencing energy burdens. A potential equity pitfall would be an inequitable distribution of access to renewable energy generation from community solar projects, for example, if wealthier residents are the program's primary beneficiaries. This pitfall could be avoided by designating some or all of the community solar specifically for low and moderate-income residents.

Implementation and Key Actions

The key activities for implementation of this action are provided in the tables below. For this Action, the intent is to design, develop and implement a program that will provide greater support to residents and businesses for installing community solar systems and providing the community solar generated discount electricity to Cambridge residents and businesses.

Table 4-11. Key activities for implementation of Action 3.2.2 – On-site Renewable Electricity Access

Short Term Activities (1-2 Years)
1. Program design and development A feasibility study of a third-party program will be undertaken. For the community solar offering, the study will determine how core functions of the program could be implemented via a third-party solar administrator; the solar administrator could determine target customers, engage with building owners and negotiate agreements with solar developers to

[17] See: https://www.mass.gov/solar-massachusetts-renewable-target-smart

streamline the timing, cost and technical design of community solar installations. The administrator would also establish data collection and compilation methods for program tracking purposes. For the long-term viability of the program, the study would also propose options for sustained funding source(s) for the third-party administered program.

2. Implement community solar program

Once the activities above are completed, the City could release an RFP for a community solar administrator, or examine other models to increasing on-site solar deployment.

Medium Term Activities (3-5 Years)

3. Provide solar access to all populations and explore additional options to deploying on-site solar

Within the next five years, the City/program should continue to establish the community solar model and expand access to solar for all populations, with an emphasis on low and moderate-income residents and residents without access to solar, while maximizing the amount of on-site solar deployment.

4. Assess integration with virtual microgrid concepts

This activity may connect the on-site solar development with Action 3.1 by integrating program projects with Virtual Microgrid concepts.

Long Term (5+ Years)

5. Integrate with Enhanced Community Aggregation Program

Over the longer term, the community solar program could be integrated with the resources of Action 4.1 – Local Carbon Fund (Enhanced Community Aggregation program).

4.3.3 Action 3.3 – Off-Site Renewable Electricity Access

Overview

While energy efficiency and on-site renewable generation will contribute to buildings achieving net zero emissions, they are not enough on their own to achieve the net zero goals of the City. The dense urban context in Cambridge and high energy use intensity of certain land uses require that off-site renewable electricity access be a part of the mix. Not all off-site renewable contracts have the same impact, however. When seeking to procure off-site renewables, it is necessary to adhere to certain criteria to have a positive impact. These include those items outlined in the City's Off-site Renewable Energy Criteria such as:

1. That a procurement supports a renewable energy project that is new and would not have happened except for the intervention of the City or other entity within the City;
2. The RECs must be assigned to the building or aggregated portfolio of buildings in Cambridge and cannot be traded for the duration of the contract;
3. The source is a renewable energy generating system that meets City guidelines.

Interplay with other Actions:

Action 1.2 – BEUDO Performance Requirements
A key element beyond energy efficiency to BEUDO subject entities achieving their performance requirements will be access to renewable sources of electricity. Therefore the criteria defined here will help achieve the goals of Action 1.2.

Action 2.1 – Net Zero New Construction
Because many new construction projects cannot achieve net zero status without purchasing RECs, the criteria defined in this action will be used by those buildings to achieve the NZE goals of Action 2.1.

Under this action, these criteria will be adopted more formally so that corporate entities and others have the guidance they need to enter into renewable power purchase agreements that meet the standards of the City. Further, this action aims to provide residents and small businesses access to renewable energy through aggregation, levering the combined purchasing power of the community. The pace of increased renewable electricity on the grid through the state Renewable Portfolio Standard will affect the priority of this action, and the City should support efforts to accelerate the development of renewable electricity at the state level.

Cross-Cutting Issues

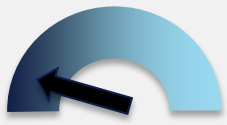
Renewable Thermal Systems	• Provides renewable electricity to electric-based equipment
Climate Change Preparedness & Resilience	• Limited
Electric Transport	• Helps reduce emissions by providing renewable electricity for charging vehicles
Capacity Building	• Community aggregation may be a key vehicle for delivering off-site renewable electricity

Contribution to Net Zero Objective

Enabling Action and has a Direct Impact on Emissions

The purpose of this action is to facilitate access to renewable energy resources when demand reduction, and on-site renewables are not adequate for meeting NZE performance targets. The pace of increases of renewable electricity on the regional grid will determine the extent to which supplemental renewable electricity sources are needed.

Anticipated Level of GHG Reductions



0 MT **10 Million MT**

Est. Cumulative Emissions Reductions By 2050

This action is considered an enabling action in that it provides the guidance needed for emissions reductions to be achieved in other actions such as Action 1.2 BEUDO Performance Requirements and 2.1 Net Zero New Construction; however, through community aggregation, this action will also provide residents and small businesses access to City compliant off-site renewable electricity. Those avoided emissions are accounted for here.

Equity

Equity Rating:

Neutral

Under this Action, Cambridge would facilitate access to grid-connected renewable energy sources when on-site renewables and other measures – like energy efficiency and demand reduction – are not sufficient to reach the City's net zero targets. While this action targets buildings subject to Net Zero New Construction and BEUDO – and, later, small businesses and residences – the City should be mindful that the cost of off-site renewable energy sources (if those resources turn out to be more costly) are likely to get passed on in the form of increased energy costs, creating a potential equity pitfall. Increased energy costs would be of the greatest harm to the City's most vulnerable residents and small businesses – particularly those paying energy costs greater than 30 percent of their income.

Procuring off-site renewable energy also entails potential equity benefits. The low operational costs of renewable electricity can result in energy cost savings and less price volatility for vulnerable Cambridge residents, depending on the ultimate distribution of program costs and benefits. As the state-wide, region-wide, and nation-wide share of renewable energy grows, there is less need for existing or new fossil fuel resources. An indirect potential equity benefit is that vulnerable, frontline communities beyond Cambridge's borders stand to benefit the most from the reduction of fossil fuel use.

Implementation and Key Actions

The key activities for implementation of this action are provided in Table 4-12. At the core of this action is the development of criteria for building owners to follow when seeking to enter into contracts to purchase grid-supplied renewable electricity and pathways to purchasing qualifying electricity; however, as the program matures, this action will also seek to enable the purchase of grid-supplied renewable electricity by residents and small businesses through aggregation.

Table 4-12. Key activities for implementation of Action 3.3 – Off-Site Renewable Electricity Access

Short Term Activities (1-2 Years)

1. Formalize and adopt off-site renewable electricity criteria

Finalize the criteria for off-site renewable electricity procurements that is currently drafted. Consideration may be given to a location criterion and the possibility of offering incentives for procurement from in-region projects. For Virtual Power Purchase Agreements, specific criteria may be developed for Large Commercial entities. The BEUDO performance requirements described in Action 1.2 may provide a vehicle for these regulations.

2. Program design - develop compliance options

Two separate pathways should be designed for compliant off-site renewable electricity purchases: the municipal aggregation program and power purchase agreements. Structural constraints and the lead time to accessing new renewable energy developments should be considered for both pathways. As part of this activity, how the off-site criteria administration can be best integrated with existing building regulations and permitting processes should first be determined.

3. Develop information resources

To support the purchasing activities, a central repository of informational resources will be created along with technical support such as through a helpdesk able to address the questions and information needs of building owners and property managers.

Medium Term Activities (3-5 Years)

4. Implement City-sponsored aggregation pathways

Within the next five years, a municipal aggregation pathway for residences and small businesses should be implemented, with a potential opt-in pathway for BEUDO buildings as appropriate. This could be initiated as soon as the next aggregation contract beginning in 2023, but new renewables would take additional time to be developed and delivered to the aggregation.

Long Term (5+ Years)

5. Integrate with enhanced Community Aggregation program

Over the longer-term, the renewable electricity procurement mechanisms, resources and support established here should be integrated with an enhanced Community Aggregation program as outlined in Action 4.1..

4.4 Action Area 4 – Financing and Capacity Building

Identifying upfront capital to achieve long-term energy savings and GHG reductions is often cited as the greatest obstacle to building owners completing more energy retrofit projects. This revised action is aimed at providing building owners the resources they need to make informed decisions about energy improvements and a means to access financing or funding for their projects. Further, this action is intended to lay the groundwork for various aspects of an enhanced Community Choice Aggregation program (CCA 3.0). The CCA 3.0 model is intended to allow residents and businesses the opportunity to own distributed energy resources (DER) using "green bond" financing to purchase the distributed energy systems and have customers opt to buy shares in the DERs, thereby conferring an ownership share to the participants and allowing the participants to realize the cost savings that occur with DER installations. By buying shares in DERs, customers can participate in DER ownership without high upfront capital costs or good credit, or even participate as renters. CCA 3.0 resolves to disengage from, rather than mitigate the impacts of fossil fuel power plants by planning and facilitating voluntary investment in local renewable energy and energy efficiency technologies. Furthermore, CCA 3.0 facilitates voluntary investment in small DERs on homes and businesses that reduce demand for grid and pipeline resources, rather than centralized renewable generation that adds to infrastructure demand. CCA 3.0 achieves equitable energy ownership, as opposed to equitable consumption of energy.[18]

[18] Local Power LLC and Peregrine Energy Group, supported by the Urban Sustainability Directors Network, "Community Choice Aggregation 3.0: Reducing Greenhouse Gas Emissions (February 21, 2020)

4.4.1 Action 4.1 Local Carbon Fund (Enhanced Community Aggregation Program)

Overview

For Cambridge to become a net zero emissions community, it will require an annual emissions balance across the entirety of the City's building stock. The primary goal of this action is to create a single point from which financial and technical resources may be deployed in order to support the emissions reductions in the other actions, thereby creating greater flexibility and coordination of compliance with those actions. The new approach to Community Choice Aggregation recommended here moves away from the standard green energy business products of deregulated energy retailers and utilities towards a local ownership pathway allowing for widespread local deployment of DERs, and energy improvements including efficiency improvements and electrification. In addition, the Aggregation program would provide funding and financing access, potentially through administering State EE and RE funds, issuing green bonds, or partnering with local banks/credit unions and other technical resources to help implement clean energy projects. This action is intended to build upon the short- and medium-term actions described in previous actions with the goal of merging into one multi-purpose aggregation program to serve the City's decarbonization strategies over the longer term.

Interplay with other Actions:

This action is supportive of:

- Action 1.1 – Custom Retrofits
- Action 1.2 – BEUDO Performance Requirements
- Action 1.3 – Upgrades at Transaction Points
- Action 2.1 – Net Zero New Construction
- Action 3.1 – Carbon Free Energy Supply
- Action 3.2 – On-site Renewable Electricity Access
- Action 3.3 – Off-site Renewable Electricity Access

Cross-Cutting Issues

Renewable Thermal Systems	• This program may be used to encourage electrification as part of the energy efficiency programs
Climate Change Preparedness & Resilience	• May be used to promote local on-site renewable energy generation that could serve as backup power such as battery storage, as well as micro-grid concepts
Electric Transport	• May be used to encourage the installation of charging infrastructure through incentives or more favorable financing
Capacity Building	• Building capacity is the primary pupose of this action

Contribution to Net Zero Objective

Enabling Action

This action would have a high impact on increasing the number of energy efficiency and electrification projects completed. To date the City, CEA, and Energy Advisor programs have had good results in engaging building owners in energy efficiency programs, but fewer projects have moved forward through completion. This action would provide a mechanism by which projects, companies and individuals could achieve net zero emissions through having better access to energy efficiency and electrification resources and financing and be able to participate in renewable energy purchasing programs. It also would provide a flexible mechanism for buildings to comply with net zero requirements, thus adhering to

the NZAP principle of allowing offsets through an offset program that maximizes local benefits. The fund would be designed to catalyze purchasing and participation in the development of local renewable energy projects or energy retrofits.

Anticipated Level of GHG Reductions

This action is considered an enabling action. By implementing this action and providing access to financing as well as capacity for building owners to take action on energy improvement projects, emissions reductions could be realized in Action 1.1, Action 1.2, Action 1.3, Action 2.1, Action 3.1, and Action 3.3.

Equity

Under this Action, Cambridge would provide access to financing for projects, and provide businesses and households access to energy efficiency and electrification information, renewable energy purchasing programs, and other opportunities to invest in the clean energy transition. Doing so would provide the City with the potential to take advantage of positive equity impacts because:

Equity Rating:

Positive

- More energy efficient homes and businesses improve indoor comfort and air quality and lower energy bills – improvements that are of the greatest benefit for vulnerable populations, particularly those with increased risks from poor indoor air quality (such as residents with respiratory conditions or residents that are home bound) and households and businesses experiencing energy burdens;
- More financing and funding for efficiency and electrification upgrades has the potential to increase access to these improvements among Cambridge residents and overcome existing equity barriers like creditworthiness and capital expenditures;
- Energy aggregation purchasing programs enhance customer engagement, which helps ensure procedural equity and broadens and deepens customer participation in energy aggregation programs;
- Energy aggregation purchasing programs enhance customer investment and ownership structures, which create new value structures that are designed to benefit all community members – including those that cannot invest directly; and
- Energy aggregation purchasing programs enhance flexibility by allowing customers to choose whether to invest directly and whether to participate in the program at all.

Implementation and Key Actions

The key activities for implementation of this action are provided in the table below. The primary goal of this action is to create a single point from which financial and technical resources may be deployed in order to support the emissions reductions in the other actions.

Table 4-13. Key activities for implementation of Action 4.1 – Local Carbon Fund

Short Term Activities (1-2 Years)
1. Enhance CEA Support and Function The Cambridge Energy Alliance (CEA) has been in operation for over a decade. Under this activity the City will improve and refine CEA as a resource hub for energy management information for homes and small businesses primarily in support of the retrofit actions and on-site solar action with a focus on equitable engagement of hard-to-reach populations.
2. Generate list of financing options Building off of Activity 5 in Action 1, a listing of financing mechanisms will be generated that housing developers and owners may access, organized by sector.

3. Identify a pathway for establishing revolving loan fund

The proposed amendments to the BEUDO ordinance contemplate a mechanism for building owners to make alternative compliance payments if unable to achieve required GHG reductions. A revolving fund should be established in a manner that avoids conflicting with statutory limitations on investment of city funds and allows funds to be earmarked for programs and projects that reduce GHG emissions throughout the building sector. The City should also continue to investigate the feasibility of establishing a third-party administered fund as recommended by the Local Carbon Fund feasibility study.

4. Program design - Enhanced Community Aggregation model development

In addition to these other short-term activities, the City should continue to explore and define the structure for a CCA 3.0 model for Cambridge leveraging the relevant activities from other NZAP actions that are supportive of the design of the CCA 3.0 to build the case for a comprehensive aggregation program.

5. Investigate acquiring State energy efficiency funds

Study the potential advantages, disadvantages, and feasibility of acquiring the state energy efficiency and renewable energy funds collected through utility bills by establishing a Program Administrator. Such a role may provide a funding source and information instrumental to a successful CCA 3.0 program.

Medium Term Activities (3-5 Years)

6. Develop the operational model for the CCA 3.0

Building on the above activities, a mechanism should be identified to collect and distribute the funding needed to complete energy efficiency and electrification projects. The City should then reassess and confirm the practicality and feasibility of pursuing a CCA 3.0 model.

7. Link relevant activities from other Actions

If the feasibility of the aggregation program is confirmed, activities from other actions would be linked to capital and needs and offered through the aggregation program.

Long Term (5+ Years)

8. Implement Enhanced Community Aggregation Program

Over the longer term, a Carbon Fund/CCA 3.0 program should be implemented. The program would be established as the primary vehicle for facilitating net zero emissions actions for homeowners, renters, and business owners by providing them access to resources for demand reduction, electrification projects and renewable energy resources and creates universal ownership opportunities.

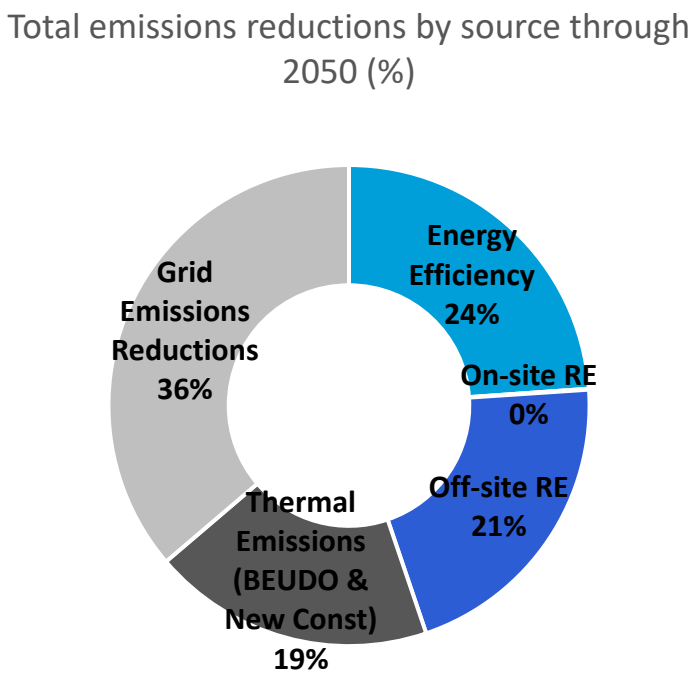
5 ESTIMATED IMPACTS OF ADJUSTED ACTIONS

Throughout the NZAP review and update process, estimates of emissions impacts were made to inform Task Force discussions and arrive at a mix of actions that could achieve the net zero emissions goals. As the adjustments to the list of actions came into focus, a more comprehensive model providing future emissions projections was created. This modeling showed that the net zero emissions reduction goals are achievable with the mix of actions proposed as part of the 2021 NZAP Update. However, achievement of the 2030 science-based target requires an aggressive ramp-up of emissions reductions activities including significant action by BEUDO buildings, additional renewable energy from the electrical grid, and rapid decarbonization of thermal energy supply through electrification and/or district energy technology.

It should be noted that any model is merely a representation of the future and therefore should not be relied on as a precise prediction. The Net Zero Action Plan is meant to be a high-level framework for action to reduce GHG emissions from buildings and lacks the specificity needed to model precise results, such as exact kWh and therms reduced by an action in a certain building sector. Therefore, rather than expecting the NZAP model to determine whether Cambridge will hit specific GHG reduction targets, it should be used to observe the general magnitude of impact of each action relative to the other actions and the interaction between them, such as whether renewable electricity will come from the grid versus local renewable electricity procurements. The model is a tool that can be adjusted over time and used to track more specific outcomes as individual actions are implemented. **Appendix G** explains the methodology and assumptions behind the NZAP model.

The emissions reductions achieved by the Net Zero Action Plan are associated with three main strategies: energy efficiency, renewable energy, and electrification of thermal emissions. These strategies align with the three pillars of decarbonization. Achieving the net zero goals also relies on the wider electricity grid becoming cleaner, with more renewables generating power being integrated over time, which will be driven by Commonwealth policy and goals. Figure 5-1 shows the share of emissions reductions anticipated from each of these to meet the 2050 goals.

Figure 5-1: Share of emissions reductions anticipated by decarbonization strategy



The 2021 NZAP Model was built to consider the emissions reduction benefits from energy efficiency, on-site renewable energy and off-site renewable energy for each action. If an action does not result in savings from energy efficiency, for example, then there would be no emissions reduction from energy efficiency for that action. If an action resulted in emissions reduction from energy efficiency and renewable energy procurement (Action 1.2 BEUDO Performance Requirements for

example), then the emission reductions are the sum reductions from the efficiency improvements and renewables.

When looking at the projected savings potential from the decarbonization strategies in both Figure 5-1 and Figure 5-2, it can be seen that, while energy efficiency and demand reduction play a role in achieving the net zero goals, it is the ability of corporate entities, residents, and small businesses to switch off of fossil fuel-based thermal energy and access enough renewable electricity that will determine if the net zero goals are achieved.

This finding differs from the 2015 NZAP, which determined that to meet the net zero goal, the majority of emissions reduction would need to come from load reduction (energy efficiency). The difference is that access to off-site renewable electricity was not considered in the original NZAP model outside of the state Renewable Portfolio Standard. The general approach was focused on maximizing on-site solar potential and mitigating the remaining emissions through load reduction strategies. The analysis used for the 2021 NZAP Update considered historical participation in energy efficiency programs, as well as the technical and economic feasibility of significantly reducing energy consumption in existing buildings. With energy efficiency potential limited by technical and economic constraints, it was determined that the majority of emissions reductions will likely need to come from the procurement of renewable energy. Since most on-site solar is incentivized by state programs that re-sell the RECs (renewable energy attributes) to other parties, those emissions savings cannot be attributed to Cambridge. Figure 5-2 shows the projected emissions reductions by decarbonization strategy through 2050 with these limitations factored into the updated NZAP model.

Figure 5-2: Projected emissions reductions by decarbonization strategy through 2050

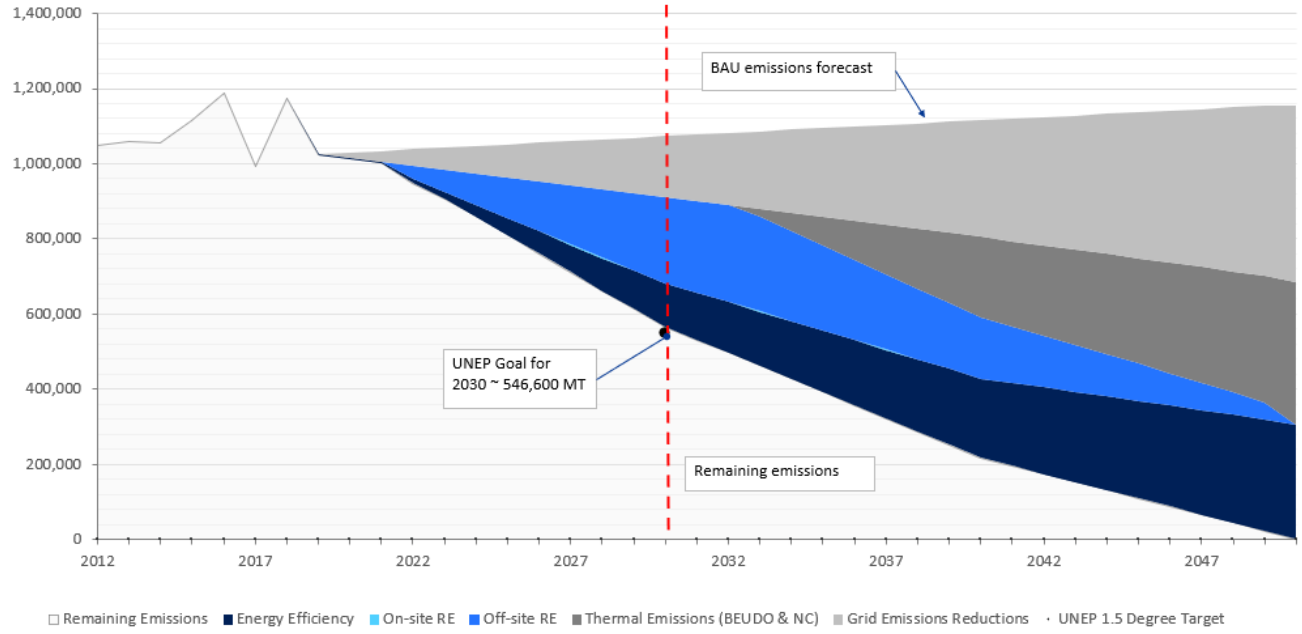


Figure 5-3 and Figure 5-4 shows the estimated emissions reductions by action. They show the anticipated emissions reduction for actions that are considered to have direct emissions impacts, assuming rates of adoption/policy requirements as described in Section 4 of this Plan and current state policy. Enabling actions are not shown. The figures highlight the importance of the BEUDO Performance Requirements (Action 1.2) and the state grid emission reductions with respect to the other actions and the overall goals. The electrical grid and BEUDO emission reductions are also highly interactive; the more renewable electricity that is provided by the electrical grid, the less renewable electricity that has to be directly procured by BEUDO buildings, and vice-versa. The state grid mix similarly affects the impact of additional renewable electricity procurement for non-BEUDO buildings via the City's aggregation program. Independent of the state grid are the emissions

from fossil fuel combustion that must be eliminated by BEUDO buildings, non-BEUDO residential buildings (Action 1.3), and non-BEUDO commercial buildings (Action 3.1). The rate of decarbonization of these buildings will be impactful in meeting the 2030 UNEP goal. The decarbonization of these thermal energy uses, however, will ultimately also be dependent on access to renewable electricity either through direct procurement or the state grid.

Figure 5-3: Projected emissions reductions by action through 2050

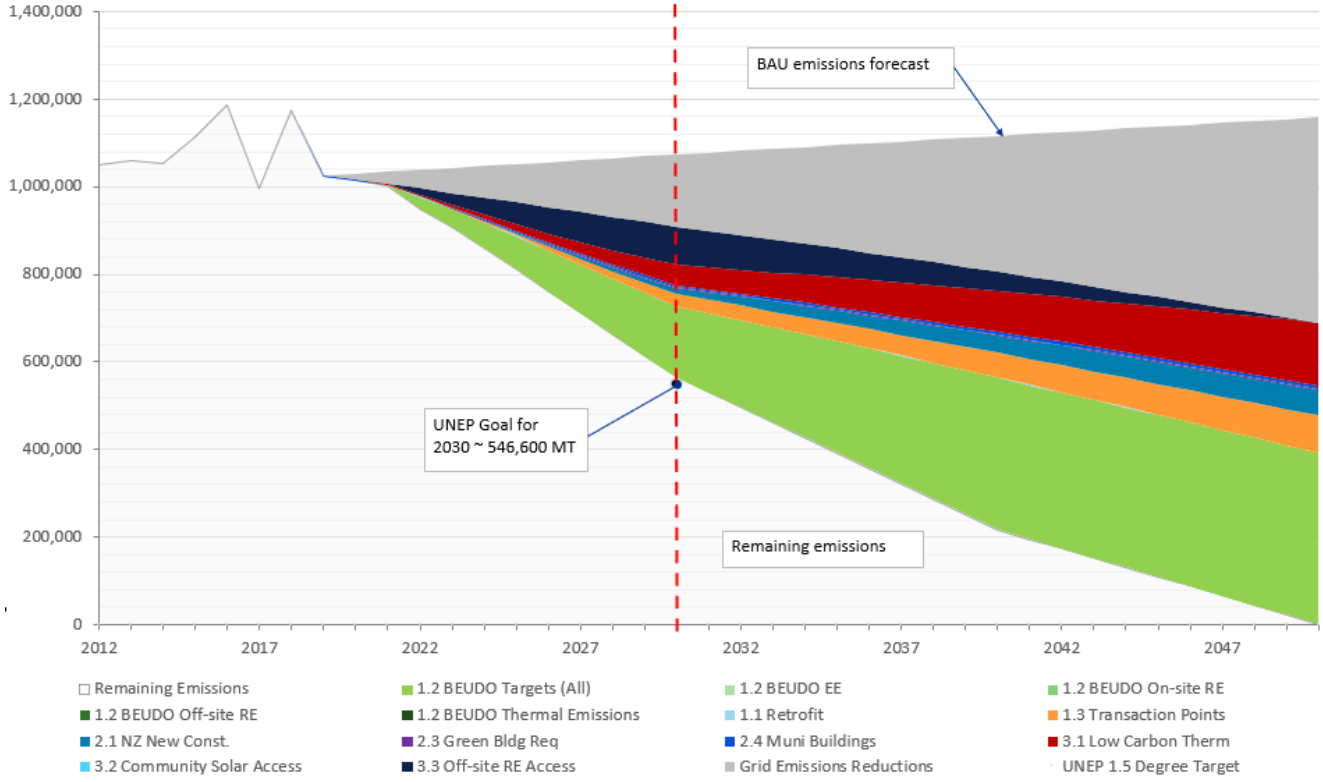
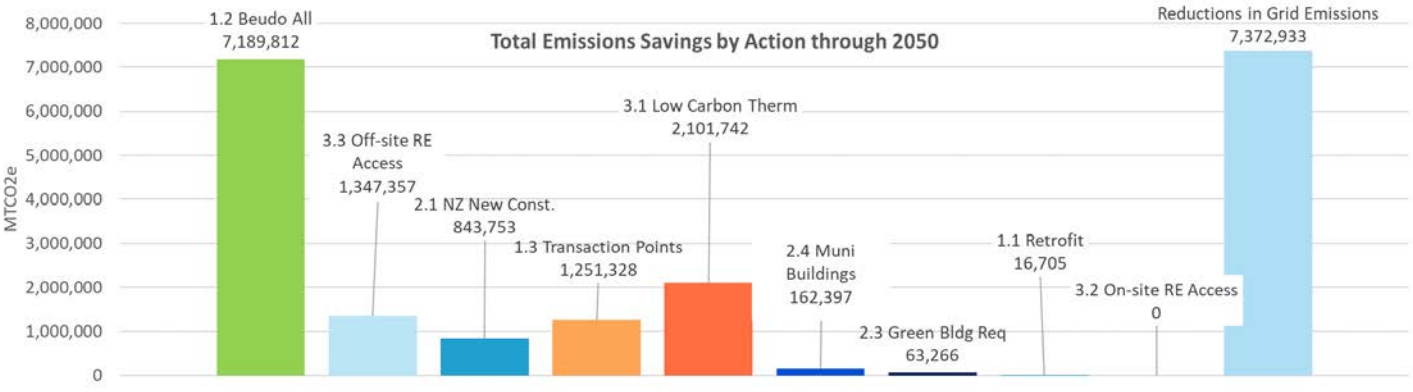


Figure 5-4: Cumulative Emissions Reductions by Action Through 2050



Notes:
1. Emissions reductions at the Action level may be realized through multiple decarbonization strategies (i.e., energy efficiency and renewables)
2. No emissions reductions are attributed to on-site renewables (Action 3.2) because of the issue with RECs not being maintained within the City.

6 RECOMMENDATIONS FOR OPERATIONAL REQUIREMENTS AND IMPLEMENTATION

While there is a need to demonstrate bold leadership and set goals today, there is also a need for ongoing management of this initiative to ensure that the targets remain relevant and achievable for the community. The City should continue to work to identify tools, innovative ideas, training opportunities and other resources to support residents and commercial property owners in working toward this aggressive, but necessary goal of net zero emissions by 2050. This section outlines the management and operational requirements for implementing the NZAP. As noted in Section 4, two Actions from the 2015 NZAP have been integrated into this operational plan and are no longer considered Actions on their own. These include:

- Action 5.1, Communications Strategy: This strategy is on-going it has been integrated here with the NZAP operation requirements
- Action 5.2, Ongoing Capacity to Manage NZAP: Similarly, this is considered part of the on-going management of the NZAP

6.1 NZAP prioritization

Successful implementation of the updated Net Zero Action Plan will require careful planning, coordination, and partnerships to move the many Actions and Activities forward on schedule. **Appendix A** shows a proposed implementation timeline for the updated Actions and key Activities. The timeline seeks to reflect the prioritization of each Action that was discussed and agreed on by the Net Zero Task Force in meeting 5. As shown in Figure 6-1, each Action was rated for its GHG reduction potential, resilience benefits, other co-benefits, equity, and "Consider.it" polling results of the Task Force members. The Task Force considered each of these factors and worked together to arrive at an "adjusted ranking" for each action to indicate the holistic prioritization of that Action in the view of the Task Force. While all of the final recommended Actions are important and should be pursued, this prioritization is helpful for assessing the amount of resources assigned to each Action and the order in which they may be pursued. The results of this prioritization will be discussed in the annual implementation reports going forwards and can be reviewed and adjusted by Climate Protection Action Committee oversight as well as the next five-year review.

Figure 6-1: Cambridge NZAP adjusted actions ratings by various metrics

Cambridge Net Zero Action Plan

Adjusted Actions Ratings by Various Metrics of Interest

Action numbe	Type	Action	**GHG Impacts Rating	**Resilience Rating	**Other Co-benefits Ratir	Summed Benefits Ratin	*Avg Score (Consider.it	***Equity Rating	TF Adjusted Ranking
1.2		Action 1.2 BEUDO Requirements	3	2	2	7	80	Flagged	1
4.1	Enabling	Action 4 Local Carbon Fund (Aggregation 3.0)	N/A	3	3	6	64	Positive	2
3.3	New	Action 3.3 Off-site Renewable Energy Access	3	1	2	6	62	Flagged	3
2.1		Action 2.1 Net Zero Requirements for New Construc	2	3	2	7	71	Flagged	4
2.2	New	Action 2.2 Address Embodied Carbon through Green	1	2	1	4	30	Neutral	5
1.3		Action 1.3 Upgrades at Transaction Points	2	3	3	8	39	Flagged	6
1.1		Action 1.1 Custom Retrofit Program	1	3	3	7	6	Positive	7
3.1		Action 3.1 Low Carbon Energy Supply	N/A	3	1	4	47	Positive	8
3.2		Action 3.2 On-site Renewable Energy Access	N/A	3	3	6	70	Neutral	9
3.2.1		Action 3.2.1 Rooftop Solar Requirement	1	3	3	7	49	Flagged	10

Notes:
*Avg. Score (Consider.it Poll): Average priority score given in Consider.it by TF members
**GHG Impact, Resilience and Other Co-benefits rated 1-3 with 3 having the highest positive impact, and 1 having lowest impact
***Equity ratings: Positive > Action having a positive impact, Neutral > Actions that have neither positive or negative impact, Flagged > Should be designed to address equity concerns/opportunities
"N/A" indicates that that Action is enabling or supporting emissions reductions in another Action

6.2 Key partnerships

While the Community Development Department will remain the primary implementation agency for the Net Zero Action Plan, support from and coordination with other City departments such as the Department of Public Works and Inspectional Services along with external actors will be essential to the success of each Action.

The achievement of net zero interfaces with a number of other City objectives and concurrent planning initiatives, including:

- Climate Protection Action Committee (CPAC) – CDD staff will ensure that annual progress updates proceed and are reviewed by CPAC to ensure accountability and transparency.
- Resilient Cambridge – The climate adaptation plan resulting from the Climate Change Preparedness and Vulnerability Assessment with a range of recommendations for buildings in Cambridge, including energy resilience.
- Envision Cambridge – The citywide plan adopted in 2019 centered on the core values of livability, diversity and equity, economic opportunity, sustainability and resilience, community health and wellbeing, and learning. The plan includes goals, indicators, and targets for climate and environment, including a 2030 emissions reduction target of 50% below 2012 levels.
- City Council Climate Crisis Working Group – A group of community advocates and local and state climate experts working over the course of fall 2021 to provide a prioritized list of specific actions the City can take to address the urgent challenge of climate change.

As noted in Section 4, partnerships should be sought with outside entities that are instrumental for enabling the success of the Net Zero Action Plan. Key examples include state and local government along with the regional utilities which control essential policies, resources, and infrastructure related to NZAP Actions including the amount of renewable electricity provided by the grid and incentives for building energy retrofits. Ongoing engagement with local and regional stakeholders is also essential, beginning with those stakeholders represented by the Net Zero Task Force members. Each Action will continue to include targeted stakeholder engagement through working groups and other forums as appropriate. Furthermore, the Task Force recommended encouraging peer learning opportunities for Net Zero stakeholders to share best practices, troubleshoot barriers, and identify lessons learned that can help accelerate implementation of the Plan. The City will collaborate with the Task Force members to arrange these peer exchanges on a regular basis.

6.3 Continued program governance

The 2015 plan proposed that the whole suite of NZAP Actions be reviewed every five years. This is an important piece of the implementation of the plan as the scientific guidance behind climate change adjusts, technologies evolve, and impacts occur. These reviews allow for the overall strategy to be adjusted as needed to accommodate changing conditions and stakeholder needs. The review process will continue to utilize the expertise and guidance of a Net Zero Task Force and outside experts as needed, to support City staff in the execution of the plan.

The regular reviews of the overall strategy will continue every five years with specific stakeholder review and consultation for each of the actions as needed. The current Task Force expressed interest in a more frequent review schedule to account for quickly-changing technologies and policies related to building GHG emissions; the next 5-year review is scheduled to begin in 2025, only 3 years after the conclusion of this review process. A specific goal of the 2025 review will be to revisit the 2030 and subsequent emission reduction targets. To ensure that the framework evolves in the desired manner, the implementation of the framework will adhere to the following principles developed during the initial Net Zero Action Plan process:

- Supports long-range healthy economic strategies as well as climate goals

- Uses market-based and data-driven analysis and decision making
- Commits to identifying and testing the best available policies, practices, and technologies, and supports an openness to new ideas when circumstances change
- Commits to allowing the principle of offsets as long as it can be demonstrated that the offset produces actual GHG reductions, whether in the form of an energy efficiency or renewable energy activity
- Commits to measuring and monitoring impact over time that leads to course corrections where required
- Ensures consultation is comprehensive and engages affected stakeholders, the general public, and subject matter experts
- Commits to developing informative and replicable models that will be shared with others
- Commits to implementing the Net Zero Action Plan through a racial equity and social justice lens [added in 2020]

As part of the NZAP implementation, the City will conduct ongoing monitoring and reporting of progress toward the Net Zero Action Plan goals. Each year an annual report will be issued. These annual reports are intended to provide an overview of each action planned for that year, including the action items, progress made, and next steps to reach the annual goals. The annual report will also provide quantitative outputs as appropriate for each action, for example, the number of green buildings permitted during the past year, as well as broader outcomes such as changes in community-wide GHG emissions.

In collaboration with the City, the Climate Protection Action Committee will provide oversight, ensuring that an annual report is issued and that the actions that have been taken to implement the NZAP and track greenhouse gas emissions trends from building operations are documented. The annual review process will provide an explicit opportunity to consider new technologies and policies that could accelerate achievement of NZAP goals and incorporate them into the Plan as appropriate.

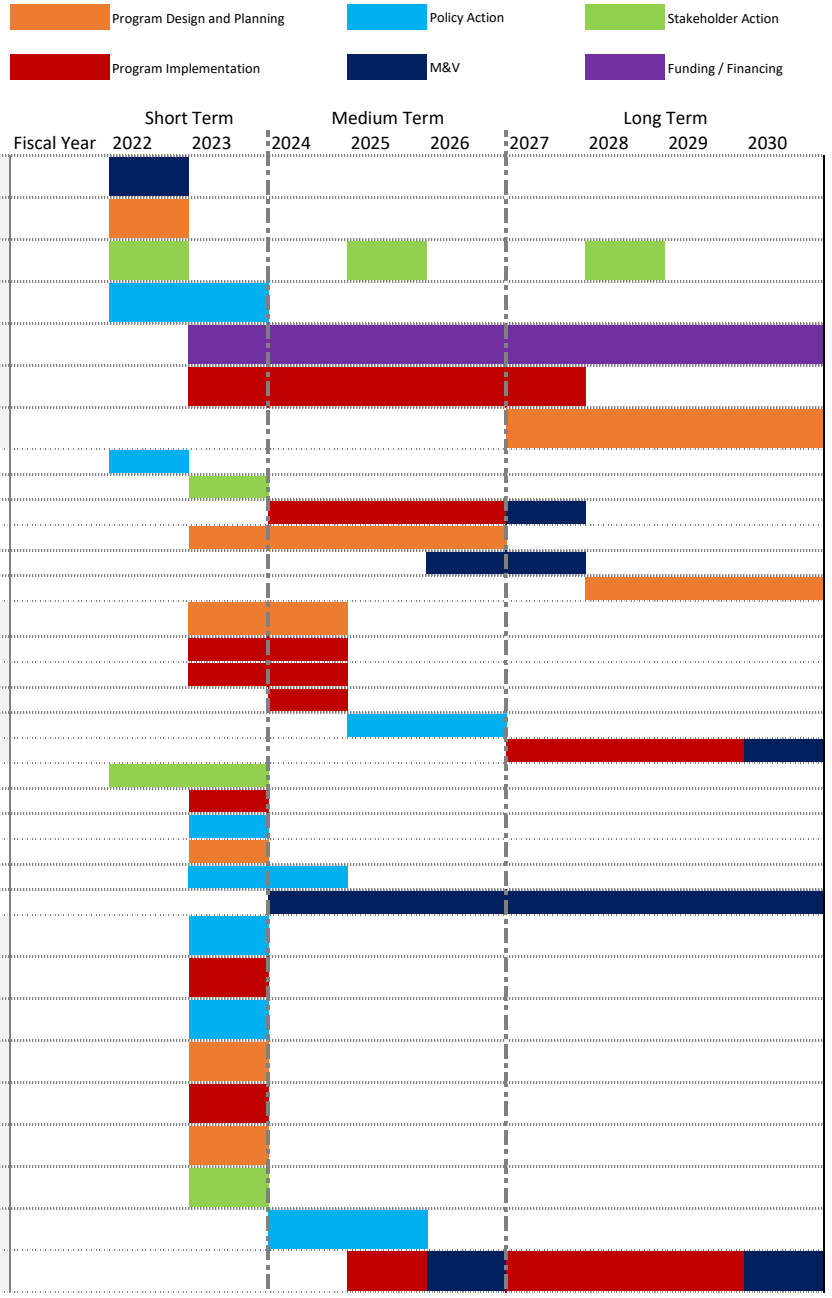
6.4 Program tracking and metrics

It is expected, as implementation of the NZAP continues, that Cambridge will see greater levels of emissions reductions as more impactful actions are implemented, including Action 1.2, BEUDO Performance Requirements, and Action 3.3, Off-Site Renewable Electricity Access. Significant work remains ahead however. By 2030, emissions need to be reduced by 600,000 MTCO2e to align with the 1.5°C Paris Agreement limit. The City needs to remain aggressive in its approach and closely monitor progress. In order to track progress more efficiently, a more robust system for reporting and tracking project-level performance data from all actions will be needed for residents, businesses, and program implementers to access. The City will work to establish such a system; a listing of the metrics needed for properly assessing impacts is included in **Appendix C**. The City will continue to receive annual aggregated energy consumption data from Eversource and update the Community GHG Inventory at least every five years. Effort should be made to collect the more granular data associated with individual NZAP actions to facilitate future 5-Year Plan Reviews. Consistent tracking and monitoring of data will also enable the City to take action and make adjustments if certain actions are not performing as expected more quickly; these data will be shared as part of the NZAP annual review process to inform activity-specific targets and adjustments.

APPENDIX A. NZAP TIMELINE

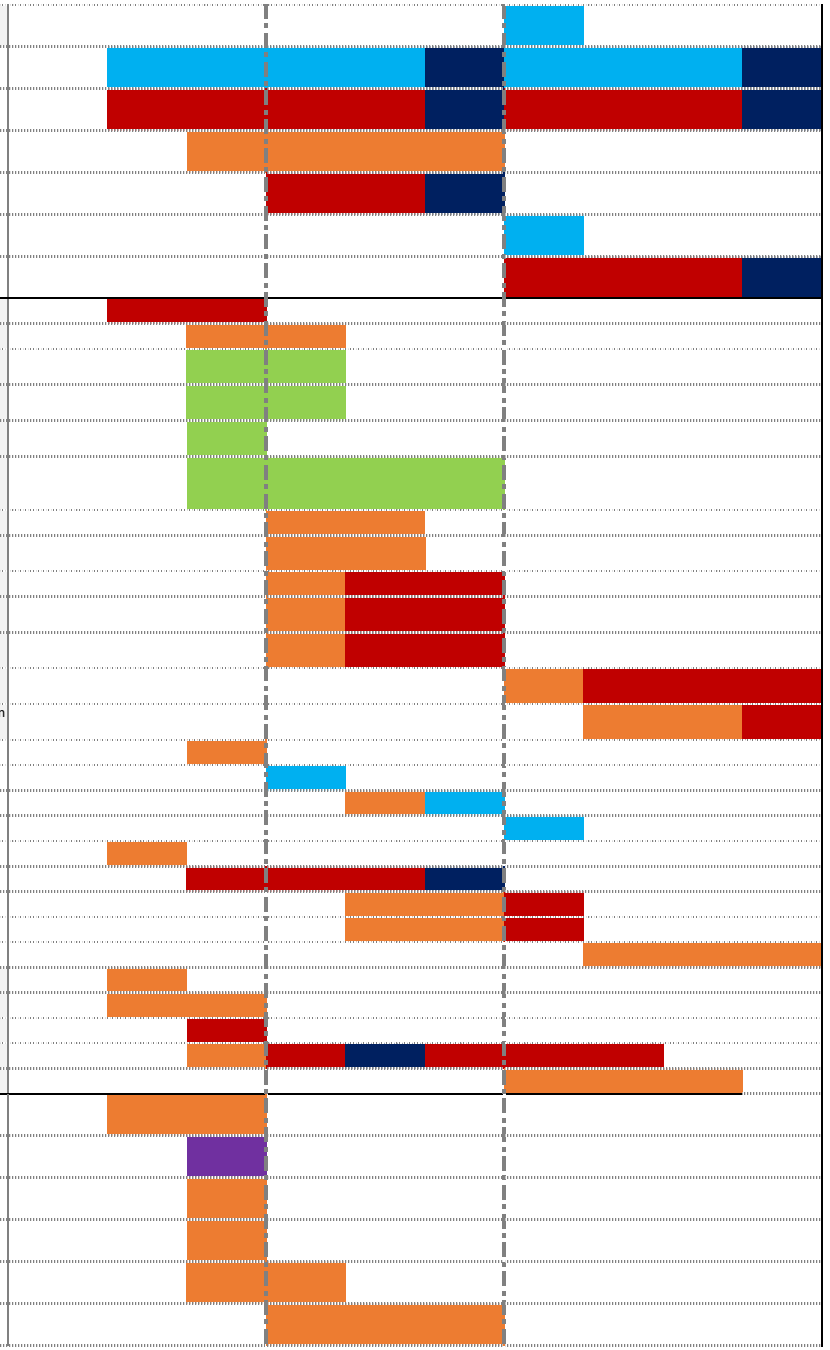
Cambridge Net Zero Action Plan
Implementation Timeline
Updated: December, 2021

Net Zero Targets



Action Area	Action	Activity
Action Area 1 - Energy Efficiency	Action 1.1 Retrofits for Residential and Small Commercial	1. Evaluate Pilot Programs
	Action 1.1 Retrofits for Residential and Small Commercial	2. Determine program adjustments
	Action 1.1 Retrofits for Residential and Small Commercial	3. Advocate for State EE program alignment
	Action 1.1 Retrofits for Residential and Small Commercial	4. Integrate Resilience and Electrification w/EE
	Action 1.1 Retrofits for Residential and Small Commercial	5. Identify means access to project financing
	Action 1.1 Retrofits for Residential and Small Commercial	6. Increase transparency in program implementaion
	Action 1.1 Retrofits for Residential and Small Commercial	7. Integrate with Enhanced Community Aggregation
	Action 1.2.1 BEUDO Performance Requirements	1. Enact performance requirement
	Action 1.2.1 BEUDO Performance Requirements	2. Establish necessary stakeholder sub-committees
	Action 1.2.1 BEUDO Performance Requirements	3. Continue to implement and monitor energy performance
	Action 1.2.2 BEUDO Resource Hub	1. Expand BEUDO Resource Hub
	Action 1.2.2 BEUDO Resource Hub	2. Evaluate Resource Hub Impacts
	Action 1.2.2 BEUDO Resource Hub	3. Integrate support with Enhanced Community Aggregation
	Action 1.3 Upgrades at Transaction Points	1. Program design
	Action 1.3 Upgrades at Transaction Points	2. Develop toolkit / templates
	Action 1.3 Upgrades at Transaction Points	3. Implement contractor education program
	Action 1.3 Upgrades at Transaction Points	4. Establish resource hub
	Action 1.3 Upgrades at Transaction Points	5. Formally adopt upgrade requirements
	Action 1.3 Upgrades at Transaction Points	6. Implement and monitor performance
Action Area 2 - New Construction	Action 2.1 Net Zero Requirements for NC	1. State-level advocacy
	Action 2.1 Net Zero Requirements for NC	2. Compile Net Zero Resources / Templates
	Action 2.1 Net Zero Requirements for NC	3. Adopt net zero stretch code
	Action 2.1 Net Zero Requirements for NC	4. Revisit and assess timeline for ZNE targets
	Action 2.1 Net Zero Requirements for NC	5. Eliminate pathways for fossil fuel use in NC
	Action 2.1 Net Zero Requirements for NC	6. Monitor performance
	Action 2.2 Address Embodied Carbon through Green Buildings	1. Adopt embodied carbon narrative for NC
	Action 2.2 Address Embodied Carbon through Green Buildings	2. Investigate LEED alternative pathways and zero carbon certification
	Action 2.2 Address Embodied Carbon through Green Buildings	3. Design and develop policy to prioritize re-use
	Action 2.2 Address Embodied Carbon through Green Buildings	4. Design carbon intensity targets
	Action 2.2 Address Embodied Carbon through Green Buildings	5. Develop toolkit / templates
	Action 2.2 Address Embodied Carbon through Green Buildings	6. Perform technical assessment of carbon impacts
	Action 2.2 Address Embodied Carbon through Green Buildings	7. Participate in peer learning sessions with other cities
	Action 2.2 Address Embodied Carbon through Green Buildings	8. Adopt LCA/carbon reduction requirements
	Action 2.2 Address Embodied Carbon through Green Buildings	9. Implement and monitor performance

	Action 2.2 Address Embodied Carbon through Green Buildings	10. Adopt enhanced LCA/carbon reduction reqs	
	Action 2.3 Net Zero Requirements for Municipal Buildings	1. NZ Req. for new construction of municipal buildings	
	Action 2.3 Net Zero Requirements for Municipal Buildings	2. Renewal of municipal buildings	
	Action 2.3 Net Zero Requirements for Municipal Buildings	3. Municipal Building Embodied Carbon	
	Action 2.3 Net Zero Requirements for Municipal Buildings	4. Renewal of municipal buildings	
	Action 2.3 Net Zero Requirements for Municipal Buildings	5. Enhanced NZE reqs. for new construction	
	Action 2.3 Net Zero Requirements for Municipal Buildings	6. Renewal of municipal buildings	
Action Area 3 - Energy Supply	Action 3.1 Carbon Free Energy Supply	1. Continue to build the Cambridge Clean Heat Program	
	Action 3.1 Carbon Free Energy Supply	2. Expand support for multifamily building electrification	
	Action 3.1 Carbon Free Energy Supply	3. Engage with development teams and partner organizations on district energy	
	Action 3.1 Carbon Free Energy Supply	4. Engage the electric utility and building owners on deploying grid-interactive technologies	
	Action 3.1 Carbon Free Energy Supply	5. Identify possible demonstration projects for low-carbon microgrids	
	Action 3.1 Carbon Free Energy Supply	6. Lead engagement with utility and state partners to understand infrastructure needs to support decarbonization and the equity implications of these changes	
	Action 3.1 Carbon Free Energy Supply	7. Create a program to facilitate local district energy connections	
	Action 3.1 Carbon Free Energy Supply	8. Examine ways to ensure the uptake of low-carbon district energy by new buildings where feasible	
	Action 3.1 Carbon Free Energy Supply	9. Workforce Development	
	Action 3.1 Carbon Free Energy Supply	10. Engage building owners in expanding building to grid or grid interactive tech	
	Action 3.1 Carbon Free Energy Supply	11. Ensure inclusion of renewable thermal in rental or transaction-point renovation	
	Action 3.1 Carbon Free Energy Supply	12. Integrate programs within Community Choice Aggregation that provide new mechanisms for renewable thermal deployment	
	Action 3.1 Carbon Free Energy Supply	13. Work with district energy system operators and legacy utilities to plan for a transition to decarbonized systems	
	Action 3.2.1 Rooftop Solar Requirement	1. Integrate Solar Requirement with Green Roof Program	
	Action 3.2.1 Rooftop Solar Requirement	2. Adopt Solar Requirement	
	Action 3.2.1 Rooftop Solar Requirement	3. Solar Requirement for Major Roof Replacements	
	Action 3.2.1 Rooftop Solar Requirement	4. Solar Requirement for Existing Buildings	
	Action 3.2.2 Community Solar Access	1. Program design and development	
	Action 3.2.2 Community Solar Access	2. Implement community solar program	
	Action 3.2.2 Community Solar Access	3. Provide access to solar for all populations	
	Action 3.2.2 Community Solar Access	4. Assess integration with virtual MG concepts	
	Action 3.2.2 Community Solar Access	5. Integrate with Enhanced Community Aggregation	
	1. Action 3.3 Off-site Renewable Electricity Access	Formalize and adopt off-site renewable energy criteria	
	2. Action 3.3 Off-site Renewable Electricity Access	Program design - develop compliance options	
	3. Action 3.3 Off-site Renewable Electricity Access	Develop information resources	
	4. Action 3.3 Off-site Renewable Electricity Access	Implement city-sponsored aggregation pathways	
	5. Action 3.3 Off-site Renewable Electricity Access	Integrate with Enhanced Community Aggregation	
Action Area 4 - Financing and Capacity Building	Action 4.1 Local Carbon Fund (Enhanced Aggregation)	Enhance CEA Support and Function	
	Action 4.1 Local Carbon Fund (Enhanced Aggregation)	Generate list of financing options	
	Action 4.1 Local Carbon Fund (Enhanced Aggregation)	Identify a pathway for establishing a revolving loan fund	
	Action 4.1 Local Carbon Fund (Enhanced Aggregation)	Program design - CCA 3.0 model development	
	Action 4.1 Local Carbon Fund (Enhanced Aggregation)	Investigate acquiring State energy efficiency funds	
	Action 4.1 Local Carbon Fund (Enhanced Aggregation)	Develop and operational model for CCA 3.0	



	Action 4.1 Local Carbon Fund (Enhanced Aggregation)	Link relevant activities from other Actions			
	Action 4.1 Local Carbon Fund (Enhanced Aggregation)	Implement Enhanced Community Aggregation Program			

APPENDIX B. IMPACT ASSESSMENT

CITY OF CAMBRIDGE NET ZERO ACTION PLAN IMPACT REPORT

Report Date: December 2020

Client	City of Cambridge	
Project Type	Actions for achieving net zero emissions	
Program Years	2015-2019	
Evaluation Firm	DNV GL	
Evaluation Engineers	Jim Leahy, Blake Herrschaft	
Project Principal	Doug Kot	

1 EVALUATION SUMMARY

The City of Cambridge has committed to achieving carbon neutrality by 2050 and has implemented a range of initiatives to support sustainable lifestyles and move the community toward greater resilience to climate change. The building stock contributes over 80% of the greenhouse gas emissions (GHG) in the city and therefore is considered a key sector to address to meet these goals. In 2013, the city convened the Getting to Net Zero Task Force, which sought to advance the conversation around net zero emissions from buildings. In 2015, the city adopted the Net Zero Action Plan (NZAP), which included a series of actions aimed at:

- Reducing greenhouse gas emissions from the built environment
- Improving energy efficiency and conservation in existing and new buildings
- Supporting renewable energy generation both on- and off-site
- Promoting best practices to engage and educate users and influence occupant behavior

The Net Zero Task Force established a principle that the suite of actions adopted under the NZAP was to be reviewed every five years throughout its implementation, and those actions be continuously monitored and adapted based on changes in GHG emission reductions in buildings and shifts in the science, technology, and policy context of GHG reduction needs and opportunities[1]. Each year since 2016, the city has issued annual progress reports summarizing the progress of each of the NZAP actions. There are five categories of actions within the NZAP that are covered:

- Action 1 – Energy Efficiency in Existing Buildings
- Action 2 – Net Zero New Construction
- Action 3 – Energy Supply
- Action 4 – Local Carbon Fund
- Action 5 – Engagement and Capacity Building

This report provides the results of an independent assessment done by DNV GL on the impacts of the various actions taken in the first five years of the NZAP. The assessment involved a review of community-wide emissions trends in recent years in relation to future goals. It also involved a bottom-up assessment wherein each of the NZAP actions were reviewed and measurable impacts were quantified. The combination of these two approaches helped determine the impact of the NZAP since 2015 and indicate the scale of action needed going forward.

Summary of Results

The review and assessment of the NZAP actions found that:

- The NZAP has laid the groundwork to reduce emissions from the City of Cambridge building stock. Progress to date includes quantifiable performance of five strategies aimed at increasing the energy efficiency of buildings, improving the performance of new construction, and providing more renewables in the energy supply; however, there is much work to do to meet the city's net zero emissions goals.

[1] See Net Zero Action Plan Website at https://www.cambridgema.gov/CDD/Projects/Climate/NetZeroTaskForce

- Nearly 1,100 buildings in the city now report their energy and water usage to the city annually through the Building Energy Use Disclosure Ordinance (BEUDO), providing valuable information for planning and with future performance requirements.
- Five NZAP Actions were identified as contributing to measurable results to date; however, the emissions savings could only be calculated for four of those based on availability of data, and the emissions savings from these actions represent only 1% of the of the total buildings sector emission in 2015.
- The long lead time in obtaining project performance data for some of the NZAP actions makes it difficult to determine the real impacts of the program over the initial five-year period. To mitigate this, it is recommended that a more robust system for reporting and tracking project-level performance data be instituted. Appendix A lists the metrics needed for properly assessing impacts from NZAP actions. While saving significant work, time, and money over having to collect performance data, it will also provide the city more insight into the progress and performance of actions.
- While it is expected the emissions trajectory will turn downward in the coming years as more impactful, more mature GHG-reductions actions and data management are implemented, the city needs to remain aggressive in its approach and find additional ways to cut emissions.

2 BUILDING SECTOR EMISSIONS PROFILE

As part of the impact assessment DNV GL reviewed the 2012 Community-wide GHG Inventory and updated the buildings sector emissions inventory for the years 2013-2018. The updated inventory provided a year-over-year emissions profile from building-related energy use in the city. The intent of compiling this information was to determine if NZAP has had observable impacts on building emissions to-date.

DNV GL gathered the information needed to generate annual CO2e emissions totals for the building sector for the years 2013-2018[2]. The emissions calculations are based primarily on electric and gas consumption in the city but include fuel oil consumption and distribution systems losses as well. This aligns with the methodology used in the 2012 Community-wide emissions inventory. The consumption data are aggregated to broad industry sectors and building types within the city. These classifications reflect the best of our ability to classify the data using the combination of the Eversource industry sectors and the MA OLIVER[3] version of Cambridge's tax parcel tax codes. Some of the groups—notably energy services—are not always discernible in the data available.

[2] Electric and gas consumption data only available through 2018 at the time of this report

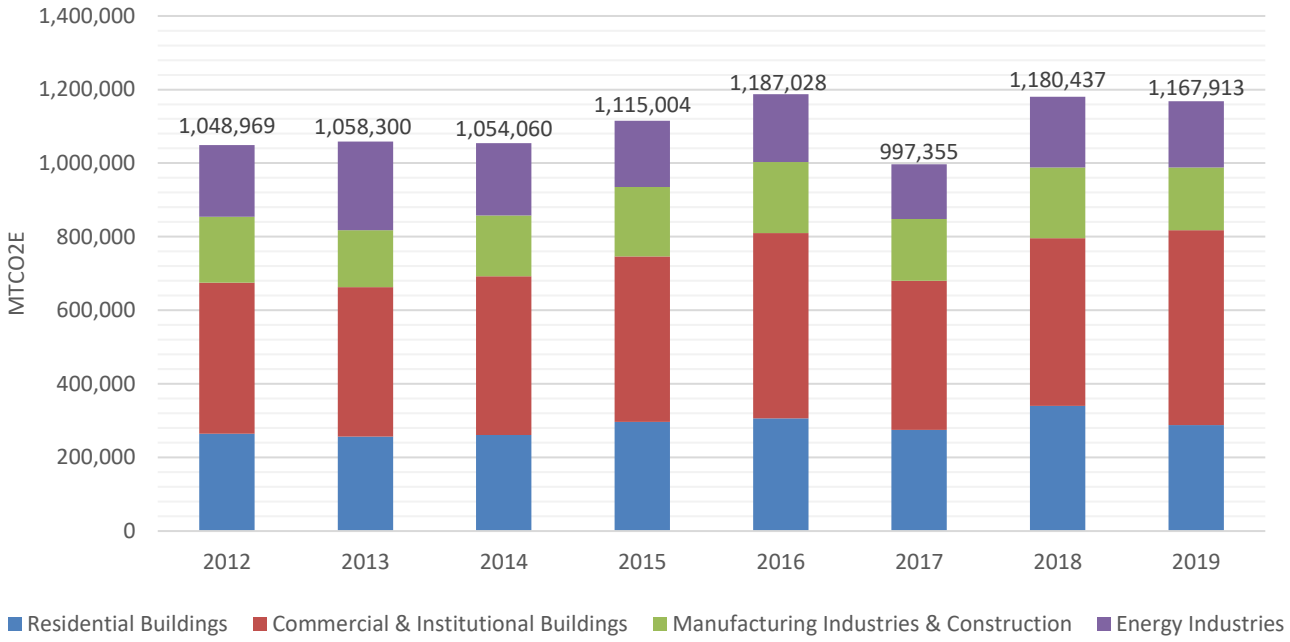
[3] Developed by MassGIS, OLIVER is an open source GIS platform accessed through the Mass.gov website

Table **2-1** provides a summary of the emissions totals for the years 2013-2018, and Figure 2-1 shows the year-over-year trends. As can be seen in the data and from Figure 2-1, emissions trends are relatively flat from 2013 to 2018.

Table 2-1: Building Sector CO2e emissions 2013-2019

Subsector	2012	2013	2014	2015	2016	2017	2018	2019
Residential Buildings	264,858	256,990	260,914	296,864	306,138	274,685	340,365	288,407
Commercial & Institutional Buildings	410,178	406,281	431,384	449,793	503,852	405,847	455,569	528,953
Manufacturing Industries & Const.	179,026	154,629	165,798	188,702	192,945	168,036	191,990	170,870
Energy Industries	194,907	240,400	195,965	179,644	184,093	148,788	192,512	179,682
All Sectors & Subsectors	**1,048,969**	**1,058,300**	**1,054,060**	**1,115,004**	**1,187,028**	**997,355**	**1,180,437**	**1,167,913**

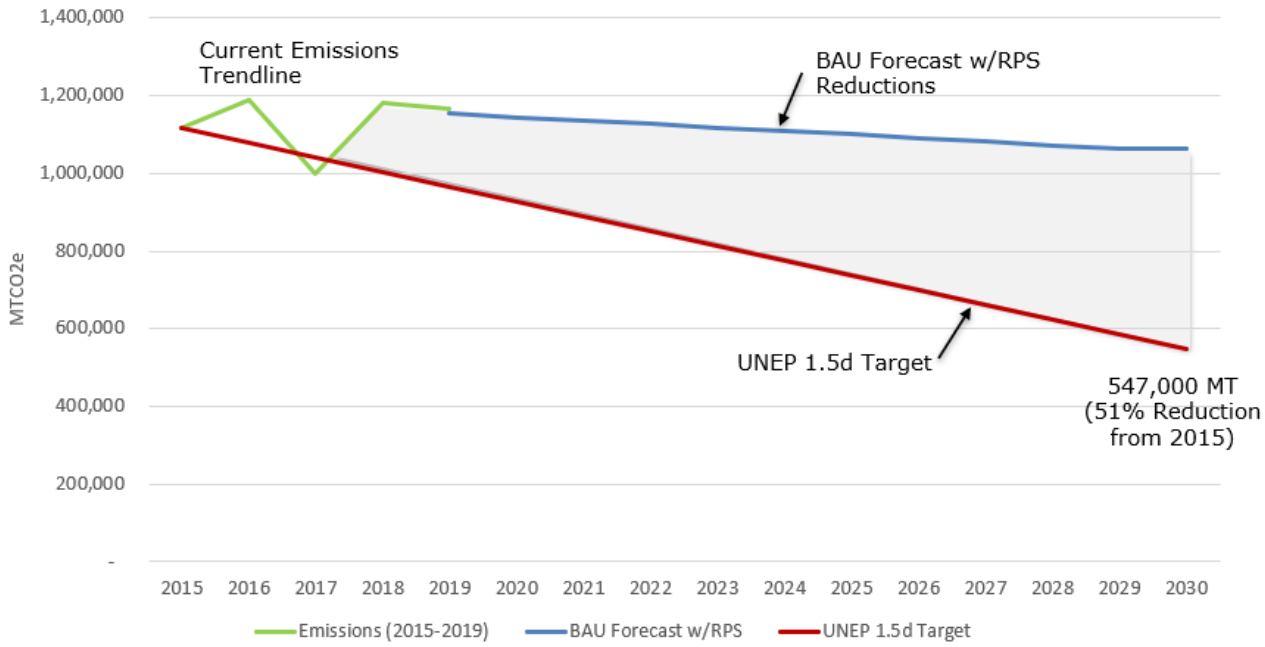
Figure 2-1: Building Sector Emissions Trends 2013-2019



To provide more context, a comparison was done of the recent emissions trends to what was anticipated in NZAP planning models. When comparing what was forecasted for year-over-year emissions reductions in the NZAP Model (adjusted to 2014 actual emissions) with the actual emissions over the same time period, there is some deviation from what was expected. For instance, in 2017, the emissions reduction target was exceeded; however, other years show higher-than-expected emissions. There are many external factors such as emissions factors, weather, and increases or decreases in assigned floor area that are known to influence emissions based on energy consumption, which limits the insight this type of assessment can provide for this short of a timeframe. Because of this, it's difficult to conclude from a top-down assessment what impacts NZAP has had on emissions from the building sector through 2018. A more detailed analysis and modeling exercise considering the variables and possible causes of changes in emissions would be needed.

Error! Reference source not found. provides a comparison of the current trajectory versus the business as usual (BAU) projections and the 1.5°C UNEP target. The current trajectory is shown as the Recent Emissions Trendline in the chart below and was based on the emissions data from 2012-2019. The BAU forecast is the expected emissions forecast into the future from 2015 if no intervention had taken place to curb emissions at the state or local level beyond the electricity emissions savings expected from the Renewable Portfolio Standard (RPS). This is based on historical population and jobs growth. What is clear is that if the current trends persist, the gap between actual emissions and the reductions needed to meet the UNEP targets will continue to increase, making it more and more difficult to achieve the City's goals for 2030 and beyond.

Figure 2-2: Comparison of Recent Emissions Trends and 2030 UNEP Emissions Targets



Notes:
IPCC, 2018, Special Report on 1.5 degrees C, issued in 2019, indicated a decline of about 45% emissions from 2010 levels was needed to not overshoot a 1.5-degree increase. This chart references the latest UNEP Gap Assessment, indicating a 51% reduction is needed from a 2015 baseline.

The BAU w/RPS is reflective of the Massachusetts Senate Bill 9 signed into law in March, 2021 which increased the RPS to achieve 40% renewable energy by 2030

3 EVALUATION OF NZAP ACTIONS

The following sections present an overview of the NZAP actions that were assessed along with the methodology used to determine the impacts of each based on information available. For this review the city provided information relevant to each of the actions being implemented including reports, models, and other data. Originally 17 actions were adopted as part of the NZAP. The status of each has been tracked in the Getting to Net Zero Action Plan annual progress reports.

DNV GL performed an in-depth review of the documentation reviewing the underlying assumptions and anticipated emissions reduction impacts of the full set of NZAP actions. DNV GL reviewed all documents and data produced relating to the 2015 NZAP actions. Table 3-1 provides a summary of the status of each of the NZAP actions. Each action is identified with its corresponding Action Number from the NZAP. The status of each action is indicated using red-yellow-green notation indicating whether the action is active, delayed, or inactive, and the stage of implementation is summarized. The four stages of implementation are: (Policy or Program) Design; Feasibility (determination of the feasibility of the action); Regulatory (enactment of the necessary regulatory framework and procedural mechanisms); Implementation. Lastly, the table includes a discussion on relative impacts on total GHG emission reductions; actions that do not result in direct emission reductions are labelled "supporting."

Table 3-1: Status of NZAP Actions as of June 2020

Action No.	Action	Status as of 2020	Description	Stage	Next Steps	Relative GHG Impacts
Action 1 – Energy Efficiency in Buildings						
1.1.1	Custom Retrofit Program		Multi-Family Energy Pilot in implementation. Custom Retrofit Program for BEUDO* buildings in implementation	Implementation	Pilot program evaluation and Custom Retrofit Program advancement	Medium
1.1.2	Additional BEUDO Requirements		Amendment proposal is ready to move forward but behind original schedule	Regulatory	Begin regulatory process	High
1.1.3	Upgrades at Time of Renovation or Sale		Time of Renovation or Sale requirement feasibility assessment completed through Zero Cities project	Feasibility	If feasible, propose policy recommendations in 2021	High
1.1.4	O&M Plan Requirement		BEUDO process included the creation of O&M plan template	N/A	O&M planning is captured through Green Building Requirements	Low
Action 2 – Net Zero New Construction						
2.1	Net Zero New Construction		Technical and economic feasibility study for net zero small residential buildings (1-3 units) completed	Feasibility	Use feasibility study as basis for policy proposal	Low
2.2.1	Market Based Incentive Program		Completed feasibility study of market incentives for new buildings	N/A	Prioritize height and FAR bonus for new buildings and consider market mechanisms for existing buildings	Low

Action No.	Action	Status as of 2020	Description	Stage	Next Steps	Relative GHG Impacts
2.2.2	Height and FAR Bonus		Determined not to be desirable as standalone policy given upcoming requirements	N/A	Seek net zero principles through Urban Design and additional Green Building Requirements	Low
2.3	Article 22 Green Building Requirements		Previously delayed requirements have been adopted	Implementation	Begin study of next round of green building requirements	Medium
2.4.1	Net Zero Requirement for New Const. of Municipal Buildings		New municipal buildings being designed to achieve net zero emissions	Implementation	Complete definitions for net zero standard	Low
2.4.2	Renewal of Municipal Building		Continued implementation of Municipal Facilities Improvement Plan	Implementation	Continue implementation and tracking of results	Low
2.5	Removal of Barriers to Increased Insulation		Previously delayed requirements have been adopted	Regulatory	Ongoing review	Low
Action 3 – Energy Supply						
3.1	Low Carbon Energy Supply		Implementation of multiple study recommendations in progress	Implementation	Complete and implement recommendations of Resilient and Renewable Thermal Analysis	High
3.2	Rooftop Solar Ready Requirements		Solar installation requirement technical analysis completed	Feasibility	Develop policy proposals for City Council consideration	Medium
3.3	Develop a Memorandum of Understanding with Local Utilities		Pursue project-specific collaboration in place of overarching MOU	N/A	Leverage collaboration with utilities	Supporting Action
Action 4 – Local Carbon Fund						
4	Investigate Local Carbon Fund		Virtual pilot complete but behind implementation schedule	Design	Use virtual pilot results to inform Local Carbon Fund design and begin establishment	High
Action 5 – Engagement and Capacity Building						
5.1	Communications Strategy		Implementation of multi-faceted communication strategy ongoing	Implementation	Action-specific and integrated stakeholder engagement activity	Supporting Action

Action No.	Action	Status as of 2020	Description	Stage	Next Steps	Relative GHG Impacts
5.2	Develop Ongoing Capacity to Manage Getting to Net Zero Project		Program Wide Review delayed due to COVID-19	Implementation	Complete Program Wide Review and implement recommendations	Supporting Action
5.3	Net Zero Labs Standards		In progress through Compact for a Sustainable Future workplan	Design	Derive conclusions and recommendations from additional benchmarking	Medium

Status: On-track Behind Parked

The primary focus over the first five years of the NZAP has been on confirming the feasibility of actions, designing the policies and programs from which the actions will be implemented, and getting the appropriate regulatory and reporting structure in place. Of the 17 actions, 6 have been implemented (i.e., the policy or program has been established and is being executed). DNV GL reviewed NZAP-related documentation and data to determine which of the actions that are being implemented have measurable results that can be used as part of the bottom-up assessment. **Table 3-2** summarizes the information that was reviewed, including which actions or initiatives were determined to have had measurable impacts.

Table 3-2: NZAP Strategy-Related Documents Reviewed

Item No.	Document/Data	NZAP Action	Impacts Currently Measurable
1.	FY16-FY19 NZAP Annual Progress Reports	Yes	Yes*
2.	Custom Retrofit Program (Action 1.1.1)	Yes	Yes**
3.	Article 22 Green Building Requirements (Action 2.3)	Yes	Yes
4.	Renewal of Municipal Building (Action 2.4.2)	Yes	Yes
5.	Rooftop Solar Ready Requirements (Action 3.2).	Yes	Yes***
6.	2014-2018 Building Energy Use Disclosure Ordinance (BEUDO) data (Action 1.1.2)	Yes	No
7.	Net Zero Requirement for New Construction of Municipal Buildings (Action 2.4.1)	Yes	No
8.	2017 Low Carbon Energy Supply Strategy (LCESS) model (Action 3.1)	Yes	No

9.	Building Intervention Point Analysis (Action 1.1.3)	Yes	No
10.	Market-based Incentives Program for New Construction (Action 2.2.1)	Yes	No
11.	NZAP Model	Yes	No
12.	2017 Community-wide GHG Emissions Inventory	Yes	No
13.	Cambridge Community Electricity Aggregation data	No	Yes
14.	2018 Climate Action Plan model	No	No
15.	2019 Zero Cities Building Stock Analysis	No	No
16.	Offsite Renewables RFP	No	No

*NZAP Annual reports list 17 actions, 4 of which were identified as having measurable impact data

**While the program has been active since 2017, data to verify savings from projects was not yet available. This is further explained in Section 4.4.1.

***The impacts of the Rooftop Solar Ready program were determined to be best assessed in aggregate with other solar initiatives per below

Based on the review of the NZAP action-related documents, we noted the following:

- Four NZAP actions were determined likely to have had measurable impacts in the first five years of the program: Custom Retrofit Program (Action 1.1.1), Green Building Requirements (Action 2.3), Renewal of Municipal Building (Action 2.4.2), and Rooftop Solar Ready Requirements (Action 3.2).
- With respect to Action 2.4.1, Net Zero Requirement for New Construction of Municipal Buildings, the NZAP has influenced the standards for design for new municipal buildings as a guiding principal, and in 2017 a policy that new municipal buildings be net zero ready was adopted. Projects that were built to these standards include the King Open School which was completed in 2019 and is fossil fuel free; 859 Mass Ave which underwent a deep energy retrofit in 2017 and installed ground source heat pumps to covers its heating and cooling needs; and the Martin Luther King School which opened in 2016 was designed to perform 69% better than baseline standards and has over 1,600 solar panel producing almost half of its electricity use. Year-over-year savings from these projects have been flagged for future assessment.
- The Building Energy Use Disclosure Ordinance (BEUDO) enacted in 2016 is considered part of the NZAP, but no emissions savings can be attributed to the action at this time. We anticipate that the addition of the performance improvement requirement will result in measurable impacts in the coming years, but this will need to be supported by a more robust system of data management. There are nearly 1,100 buildings in the city that now report their energy and water usage to the city

annually, which provides valuable information for planning, but the dynamic nature of the data makes it difficult to analyze.

- The Community Choice Aggregation program (CCA) was not an action originally adopted within the NZAP, but it is considered supportive of the Energy Supply action (NZAP Action 3) and was therefore considered within the impact assessment.
- The City's renewable energy production goals are being met by multiple solar-related initiatives including Sunny Cambridge, Custom Retrofit Solar Advisor, and Rooftop Solar Ready, and are further influenced by the Article 22, Green Buildings Requirements. Because of the overlap in the tracking data available, the best way to measure the impacts and progress toward the City's goals of increasing building integrated solar within the city was to combine the initiatives into one multi-initiative solar strategy.

The key parameters used to determine the impacts for each action were primarily energy use savings, program participation, or energy generation capacity. The approach was to identify the key parameters needed to assess the action impacts and derive total emissions savings over the five-year period using those parameters (see Table 2-3). The energy supply impacts of the CCA Action were based on participation in the Green+ product program, while participation in the CCA Standard Product program was used as an indicator of the strength of the CCA program overall.

The baseline year from which impacts are measured is 2015. Emissions, electricity, or natural gas savings are cumulative from that point forward, so that the total impact is the sum of annual savings achieved for the five-year program period (2015-2019). Where applicable, indicators of performance were captured as well, such as program participation rates.

Table 3-3: Key Parameters for Determining Impacts of Measurable NZAP Actions

Action	Key Parameters	Metric(s)	Source of Parameter Data	5-year Impact Calculation
Custom Retrofit Program (Action 1.1.1)	Electricity and Gas Savings from Participating Projects	kWh savings Therms savings Emissions savings	Participant/program implementer	Savings since NZAP inception
Article 22 Green Building Requirements (Action 2.3)	Estimated energy savings beyond code	kBtu consumption vs. baseline (% improvement)	City Building Permits	Savings since NZAP inception
Renewal of Municipal Building (Action 2.4.2)	Electricity and Gas Savings from Participating Projects	kWh savings Therms savings	City Facilities Department	Savings since NZAP inception
Rooftop Solar Ready Requirements (Action 3.2) with Multi-initiative Solar Strategy	Capacity of Installed Systems & System Production	kW kWh	City Building Permits	Production since NZAP inception
Cambridge Community Electricity Aggregation – Green+ Product	Purchase of 100% Renewable Electricity consumption	kWh	Program Implementer	Program participation and Production of RE resulting from Operational Adder

4 NZAP ACTION IMPACTS

This section provides a summary of the measurable impacts of NZAP actions. In the NZAP, individual actions are associated with their action categories: Energy Efficiency in Existing Buildings (Action Category 1); Net Zero New Construction (Action Category 2); Energy Supply (Action Category 3); Local Carbon Fund (Action Category 4); and Engagement and Capacity Building (Action Category 5). Included here are the impacts of the measurable individual actions in relation to the City's net zero emissions goals, resources available to track the progress of each action over time, and a summary of the ancillary benefits from undertaking these actions. Overall findings are compiled in Section 5, Results.

4.1 NZAP Action Category 1 – Energy Efficiency in Existing Buildings

4.1.1 Custom Retrofit Program (NZAP Action 1.1.1)

This action is part of Action 1 – Energy Efficiency in Existing Buildings. As stated in the NZAP Annual Progress Reports, this action is intended to ensure that all buildings are operating optimally and, where necessary, retrofit to maximize efficiency. After the initial program design, the Custom Retrofit Program began in 2017 with the implementation of the Multi-family Energy Pilot. The program has been integrated with BEUDO and expanded to other building sectors as part of the new Building Energy Retrofit Program. The program aims to provide building owners with a voluntary, cost-effective pathway for reducing energy use and GHG emissions. This action is supportive of future BEUDO energy performance improvement requirements (NZAP Action 1.1.2).

Current Tracking Methodology

The City currently tracks projects coming into the Multi-family Retrofit Program through documentation provided by the program implementers: New Ecology Inc., who is contracted by the City and serves as the Retrofit Advisor, and CLEAResult, the implementer for MassSave, the state-wide energy efficiency program. As of the end of 2019, 50 properties encompassing 1,450 multifamily housing units had been enrolled in the program; however, few projects are known to have been completed to date. Because of this, the data needed to determine quantitative impacts from this action are not yet available.

The Building Energy Retrofit Program is also tracking program participation and impacts through the Eversource Retrofit Consultant since the program inception in Fall 2019. As the BEUDO performance improvement requirements are implemented, it will be important for the city to distinguish between and track those retrofit projects that resulted from the initial pilot program and those that resulted from the BEUDO Building Energy Retrofit Program.

Impact Assessment

DNV GL performed an initial documentation review to determine an appropriate method for calculating program impacts from the Custom Retrofit Program. Of primary interest were the cumulative emissions savings over the five-year period since the NZAP was adopted. For this action, savings are based on:

- Information from the buildings that have completed custom retrofit projects as part of this program including measures installed and the estimated electricity and gas savings as provided by the program implementers, CLEAResult and New Ecology.
- If available, data from those residential unit that participated in the Solar Advisor program as provided by Zapotec.

The pilot program was focused on the multifamily housing sector. Savings from this action would be determined by collecting information on various aspects of the program. Ideally, the number of residential units included per project (based on enrollment); the electricity and gas consumption (pre- and post-installation); and estimated electric and gas savings per project would be provided. In this case, however, much of the project-level data was not available due to many of the enrolled projects not having been completed. Table 4-1 provides a summary of the needed and available data for calculating expected impacts.

Table 4-1: Data Needed for Multi-family Program Impact Assessment

Item	Quantity	Source
No. of units	1,450	Program Data
kWh consumption per unit per project	Not available	
Therm consumption per unit per project	Not available	
Estimated kWh savings per project	Not available	
Estimated Therm savings per project	Not available	

The Building Energy Retrofit Program is expected to result in measurable electricity, natural gas, and emissions savings based on MassSave[4] program data and will continue through FY20 with a concierge service being established to better facilitate retrofit projects and connect building owners with resources available through MassSave. The savings metrics listed in Table 4-2 can be calculated once the project-level data becomes available.

Table 4-2: Data Needed for Building Energy Retrofit Program Impact Assessment

Measure	Source
Number of projects completed	Program data
Electricity Savings (kWh)	Program data
Natural Gas Savings (Therms)	Program data
GHG Emissions Savings (MTCO2e)	Calculated

Ancillary Benefits

After a review of this action and the related activities, the following ancillary benefits were noted:

- Leadership – The city has chosen to take an active role in promoting energy efficiency in the community and has worked with Eversource (the MassSave Program Administrator) on ways to improve program participation.
- Collaboration – The establishment of this program engages the local community and facilitates discussions with stakeholders, include Eversource, the energy efficiency program administrator, around energy efficiency and ways to improve these types of programs. This is evident by the

[4] MassSave is the name for the Massachusetts Energy Efficiency Programs sponsored by the Statewide Program Administrators

stakeholder workshops that have been held which included Building Owners, Eversource, and Cambridge Community Development Department (CDD) and the solutions identified through those discussions.

- Equity – The program has promoted energy efficiency in multifamily buildings and within those communities who benefit most from reduced energy costs.

4.2 NZAP Action Category 2 – Net Zero New Construction

Article 22 Green Building Requirements (NZAP Action 2.3). As stated in the NZAP Annual Progress Reports, this action is intended to promote environmentally sustainable and energy-efficient design in new construction and major renovation projects in the city. This ordinance was updated in December 2019 to adopt LEED Gold v4, Passive House, or Enterprise Green Communities as the reference standards and require new buildings to submit a decarbonization pathway along with their permit application.

Current Tracking Methodology

The City has developed a comprehensive database of buildings that have been subject to the ordinance and tracks the number of projects and equivalent level of certification through the building permit review process. All data on the proposed new buildings are stored in the database, which includes level of certifiability, year of building permit, square feet of building, project type, building use, and the credits achieved by each project. In FY19, 16 projects were permitted following the green building review representing almost 3.5 million square feet of development, including 1,300 residential units.

Impact Assessment

DNV GL performed an initial documentation review to determine an appropriate method for calculating the impacts from the Green Building Requirement. Article 22 data dates back to 2011, well before the adoption of the NZAP; however, emissions reductions over the last five years are of primary interest. Article 22 requires subject buildings to be designed in accordance with the latest version of the applicable green building certification program. For the purposes of this impact assessment, LEED V4 was assumed to be the design standard. LEED V4 requires that non-residential buildings be designed to perform a minimum 5% better than ASHRAE 2010.

DNV GL reviewed BEUDO data to determine if actual performance data could be used to assess the impacts of building constructed under Article 22; however, few matches could be made based on building addresses, square footage, and year built. In the absence of performance data, DNV GL estimated the impacts of the Article 22 Requirements relative to the base building energy code in place in 2015 in order to provide the city an indication of the impacts of the program and guidance on how to assess impacts in the future.

In this respect, the impacts of Article 22 were based on buildings permitted since 2015 achieving an assumed energy performance improvement over baseline design. Since LEED V4 requires a modeled performance improvement of at least 5% over ASHRAE 2010, and Article 22 required subject buildings to be built to an equivalent of LEED-Silver standards up until December 2019, DNV GL estimated a 15% performance improvement over IECC 2012/ASHRAE 2010 code. Table 4-3 provides a summary of the information used for calculating emissions impacts.

Table 4-3: Information Used for the Evaluation of Article 22

Item	Quantity	Source
No. of Article 22 Project Completed (2015-2019)	54	Building Permit Data
Square feet of projects permitted	8,145,438	Building Permit Data
% energy performance improvement over ASHRAE 2010	15%	Estimated

Although LEED V4 references ASHRAE 2010 as the base code, local building codes get more stringent over time. In Massachusetts the energy code is updated every three years. At the time of the NZAP being adopted, the energy code in Massachusetts was based on IECC 2012/ASHRAE 2010, but in 2017, Massachusetts updated the codes to reflect IECC 2015/ASHRAE 2013. In addition, Cambridge had been an earlier adopter of the State Stretch Energy Code, which required a 10% improvement over base code.

It's important to consider these constantly changing baseline conditions as well as the relationship between state and local action when assessing the impacts of Article 22. For Cambridge, Community Development Department staff have continued to work with State code officials on the development of more stringent codes using their experience with the stretch energy code. Where Cambridge has led, the State codes have tended to follow. To adequately capture the effects of this interplay, DNV GL calculated the emissions savings from the original base code (IECC2012/ASHRAE 2010), which more clearly demonstrates the effects of the increase in new construction code requirements over time from which the impacts of Article 22 are based. Table 4-4 provides a summary of those impacts.

Table 4-4: Estimated Impacts of New Construction Requirements 2015-2019

Measure	Absent Energy Code Change	
	Quantity	Source
Number of projects completed	54	BP Data
Electricity Savings over 2015 baseline code (kWh)	17,894,837	Calculated
Natural Gas Savings over 2015 baseline (Therms)	471,840	Calculated
Est. GHG Emissions Savings (MTCO2e)	8,705	Calculated

Going forward, it is recommended that the emissions and energy savings stemming from of Article 22 be calculated based on the reference standard in 2015. This will capture the impacts of the change in new construction standards over time regardless of State or local action. Further, it is recommended that action be taken to ensure that the actual energy performance of buildings constructed under the Article 22 requirements are reported and tracked through BEUDO. This can be accomplished by using the common building identifier codes that the city currently uses, but property addresses, ownership, and other characteristics such as floor area must align between permit data and BEUDO reporting data.

The green building ordinance allows for a focus on emissions reductions, and the leadership the city took to enhance new construction projects early on resulted in progress toward the 2050 goals. However, until a net zero requirement is adopted, new buildings will continue to increase GHG emissions regardless of policy. The city continues to work with the State on these issues and is currently exploring the use of performance-based requirements as well as a voluntary net zero stretch code to better serve the city's zero emissions interests to address this.

Ancillary Benefits

The green building requirements have been in place for over 10 years and come with many ancillary benefits that are inherent in Green Building Design and should be recognized. These include:

- Improved health and wellbeing of the community – Green buildings have many benefits beyond energy and emissions savings, including creating healthier, more comfortable indoor working and living spaces, improvements in outdoor spaces, and access to cleaner modes of transportation.
- Equity – Green buildings are often designed with access to public transit in mind, which improves access to jobs and reduces the need to own an automobile.
- Climate resilience – Improved occupant comfort and indoor air quality reduces vulnerability to extreme temperatures and power losses and reduces risk exposure for vulnerable populations.

4.2.1 Renewal of Municipal Buildings (NZAP Action 2.4.2)

This action seeks to set an example of leadership in the energy efficient renewal of existing buildings in the city. The improvements are part of the City's facilities improvements strategy, which integrates energy improvements with life safety and accessibility. This action has been ongoing since the adoption of the NZAP.

Current Tracking Methodology

The City currently maintains a database of the city facility improvements. This data contains a description of the project, the building where the project was completed, the estimated electricity and gas savings, costs, incentives received, and funding source. Under the 2017 Municipal Facilities Improvements Plan (MFIP), performance metrics and goals were established. This provides the underpinning for a robust tracking system for this action.

Impact Assessment

DNV GL performed a review of the available documentation. Of primary interest is a determination of the cumulative emissions savings over the five years since the NZAP was adopted. DNV GL based the impact calculations on:

- The list of projects that have been completed across city facilities.
- The estimated electricity and gas savings from each project completed.

The retrofit projects for municipal buildings covered under this action span a wide range of building types and project types. Building types include office buildings, schools, maintenance, and public safety buildings. The project-level information for each building was used to determine the cumulative impacts of the action from 2015 through 2019. Streetlighting projects and outdoor lighting projects for public spaces were not included. Table 4-5 provides realized savings for this action.

Table 4-5: Municipal Building Renewal Program Realization 2015-2019

Measure	Quantity	Source
Number of projects completed	78	MFIP data
Electricity Savings (kWh)	3,906,087	MFIP data
Natural Gas Savings (Therms)	31,991	MFIP data
GHG Emissions Savings (MTCO2e)	1,504	Calculated

Overall, the city's continued investment in improving the energy efficiency of public buildings has resulted in over 1,500 metric tons of CO2e emissions reductions—about an 8% reduction in municipal building emissions since 2015. The performance is an indication of the success of the program in identifying high impact energy efficiency improvements in municipal buildings. The challenge will be maintaining that level of performance and energy savings in the years to come as opportunities for savings decrease.

Ancillary Benefits

The renewal of municipal buildings contributes positively to the community in many ways. By taking this action, the city has demonstrated:

- Leadership – The city has chosen to take an active role in promoting energy efficiency using its own buildings as examples of the types of improvements that can be made. Maintaining these valuable public resources also demonstrates the fiscal and public safety responsibility of the city.
- Collaboration – The work performed to identify improvements and determine which projects should be prioritized requires a significant amount cross-departmental collaboration. Much of this work was performed through the MFIP.
- Resilience – The MFIP provides a prime opportunity to identify vulnerabilities to climate change in critical buildings and reduce the community's risk of impacts from climate-related emergency events.

4.3 NZAP Action Category 3 – Energy Supply

4.3.1 Solar Ready Rooftop Requirements (NZAP Action 3.2)

As stated in the NZAP Annual Progress Reports, this action is intended help meet the City's net zero goals by encouraging the installation of additional renewable energy generation, namely solar. Solar Ready means that buildings can accommodate the installation of a future solar array (could be photovoltaic or solar thermal).

The primary source of information for tracking the number of solar installations that have occurred as a result of this action is building permit data; however, the permit data does not distinguish between contributing programs. Because of this, the impacts of the Solar Ready Rooftop Requirements were measured as part of the multi-initiative solar strategy (see Section 4.3.2).

Current Tracking Methodology

The City currently tracks solar installations through building permits. The projects that would be covered under the Rooftop Solar Ready action, however, are new construction or major renovation projects where the solar ready aspects are embedded within the building permit and not easily identifiable.

Impact Assessment

See Section 4.3.2, Multi-initiative Solar Strategy.

Ancillary Benefits

See Section 4.3.2, Multi-initiative Solar Strategy.

4.3.2 Multi-initiative Solar Strategy

The multi-initiative solar strategy stems from the City's aggressive pursuit of solar energy within Cambridge and there being multiple initiatives in place that promote the installation of solar systems. These include the Solar Ready Rooftop Action, the Custom Retrofit Solar Advisor program, and the Sunny Cambridge Program. While the Solar Ready Rooftop requirement and Solar Advisor program are components of the NZAP, all of these contribute to the city meeting its net zero emissions goal.

Current Tracking Methodology

The current method for tracking solar installations in the city is through building permits. The information provided in the permit database, however, does not indicate which initiative (if any) prompted the installation and the solar system. For this reason, the impacts of the solar initiatives were determined using a combined approach.

Impact Assessment

DNV GL performed a review of documentation related to the Rooftop Solar Ready Action, Sunny Cambridge, and the Custom Retrofit Solar Advisor program as well as the building permit data to determine an appropriate method for estimating the impacts of these programs. The best way to estimate the impacts from solar initiatives was to combine all solar strategies into one Multi-initiative Solar Strategy. Of primary interest is cumulative emissions savings over the five years since the NZAP was adopted.

DNV GL estimated the emissions savings from these initiatives according to the total number of solar installations that took place during the initial five years of the NZAP implementation. There has been a substantial increase in solar arrays installed in the city. From the permit data 445 solar PV systems were installed in this time period which were estimated to generate over 6,400 MWh of electricity. This is about 0.4% of the annual total kWh consumption in the city (2015). Table 4-6 provides a summary of the savings that have resulted from systems installed.

Table 4-6: Summary of Solar Installations 2015-2019

Measure	Quantity	Units
Number of installs (2015-2019)	445	Units
Average capacity of PV (kW)	11.8	kW
Total capacity of PV installed (kW)	4,969	kW
Total estimated production (kWh)*	6,410,171	kWh
Total emissions saved (estimated)	2,383	MTCO2e

*Based on PV Watts average electricity production for the Northeast

Over 6,400 MWh of capacity has been installed since 2015. To assist in the assessment of program performance, DNV GL also looked at the change in number of installs since 2015. The data shows that the average capacity of installed systems varies year to year, but that there has been a declining trend in the number of installs since 2016. New tools and financing instruments are becoming more common and may be playing a role in this. For example, in 2016 MIT entered into an agreement to buy electricity from a solar power installation in North Carolina (see MIT Solar Power Purchase Agreement). This agreement enabled the

construction of a 60 MW solar array and helps MIT achieve its climate change mitigation goals but does not support the solar systems installation goals in Cambridge.

Ancillary Benefits

The solar programs in Cambridge are a major component of the city's strategy to achieve its renewable energy production goals. The programs not only provide localized clean energy production, but also have other co-benefits, such as:

- Demonstrating leadership – The city is willing to go out and actively promote localized renewable energy, which will provide a model for other communities to follow.
- Improving health and wellbeing – Increasing renewable energy production helps improve air quality, but it also helps provide residents and business with a clean source of electricity that can be used to electrify equipment, reduce fossil fuel consumption, and minimize the combustion of gases inside buildings, which poses safety hazards.
- Increased resilience – Localized distributed energy resources increase energy security and reduce the impacts of a climate change event by providing a localized supplemental power source.

4.4 Cambridge Community Electricity Aggregation

The Municipal Electricity Aggregation program was developed by the City of Cambridge in 2017 to provide residents and businesses greater access to renewable energy options. This action is considered supportive of NZAP Action 3 – Energy Supply and is therefore considered as part of the NZAP Impact Assessment.

The Cambridge Community Electricity Aggregation (CCA) program is a two-tiered electricity purchasing initiative. There is the Standard Product, which residents and businesses are automatically enrolled in on an opt-out basis, and there is the Green+ product which is an option for those who want to purchase 100% renewable electricity. No energy efficiency work or incentives are administered through the CCA, however, in 2018 the program was redesigned to directly support the development of community solar projects within Cambridge. The current plan is to use the proceeds from an operational adder included in the supply price to fund renewable energy projects. These are planned to be developed in the coming years.

Participation in the two products and any Renewable Energy Credits (RECs) included as part of the electricity supply mix associated with the products were considered for the impact assessment; however, stemming from the 2018 redesign, the city wants to ensure that impacts are based on the concept of additionality. The term additionality refers to energy sources that generate power from *new* renewable energy sources that that would not have occurred without the City's actions and can provide evidence of reducing greenhouse gas emissions. While measurable impacts were not determined at this time, it is important to document this initiative as supporting the NZAP and discuss the tracking of data and methods for calculating future impacts.

Current Tracking Methodology

The City hired Peregrine Energy Group as the CCA consultant to oversee the implementation of the program. To track participation levels, Peregrine maintains a detailed account-level database of customers, both residential and commercial, who participate in the program. The biggest challenge in tracking and analyzing the data is that there is a lot of customer turnover year to year, especially for residential customers where there is a large student population. The other challenge is that new customers are not immediately enrolled in the program. When a customer signs up for an electric account, there is a three- to six-month window

before the account is transitioned from Eversource to the CCA. Because this transfer window may be a factor limiting participation within the student populations, its recommended that this metric be tracked.

Impact Assessment

DNV GL reviewed the data maintained by Peregrine Energy Group to determine an appropriate method for calculating program impacts. There are different layers of impacts that may be considered. First, an assessment of the strength of participation in the CCA program overall be useful to the city. Second a determination of the emissions reductions impacts that the program has resulted in. While there were some emissions reductions associated with the Standard Product program during the first few years through the purchase of Renewable Energy Credits (RECs), these credits are not to be considered emissions reductions due to a perceived lack of additionality. Instead emissions reduction should only be based on new renewable energy systems developed as a result of the operational adder, which is set at $0.002/kwh.

Strength of program participation is to be based on:

- Account-level CCA data from Peregrine Energy Group
- Billing data provided by Eversource

For example, data from 2018 shows that of the 71,527 commercial and residential accounts in Cambridge, 50,085 were participants in the CCA program (~70%). This information may also be used to create a time-series analysis to show participation trends year-over-year. It is expected that participation will continue to increase as additional community engagement strategies are rolled out aimed at educating consumers on the benefits of the CCA program and it will be important to track its level of success.

Determining the emissions reductions from a renewable energy project developed as a result of the operational adder will require an inspection of the system and data one year after the system is operational. The impacts will be based on the amount of renewable energy produced from community solar projects constructed using funds raised through the CCA electricity pricing. An initial assessment may be done using design factors such as system capacity (kW or MW) and modeled annual system production (estimated kWh/yr); however, to ensure the system is performing as intended and resulting in the expected emissions reductions, the annual inspection will seek to identify any deviations from design. This may include a review of records of performance checks, maintenance and repairs, and other performance data. Appendix A provides a listing of measures to track to determine impacts.

Ancillary Benefits

The Community Electricity Aggregation is another prime demonstration of the city's leadership in undertaking actions to reduce emissions. This program actively promotes consumer choice in how residents purchase electricity and helps protect consumers against fraudulent practices in the electric retail industry. It provides access to more cost-effective renewable energy options and educates consumers on the benefits of taking a more active role in choosing how their energy is supplied. Exemplary benefits of this action include:

- Leadership – The city has taken an active role in providing local residents and businesses ready access to 100% renewable energy.
- Public health – The 100% renewable energy product helps to improve air quality and promotes a healthier lifestyle for residents of Cambridge.

- Climate change mitigation – 100% renewable electricity supply reduces the amount of GHG emissions associated with distribution system losses and overall life-cycle emissions associated with the energy supply chain.

While the emissions reductions impact of the Green+ product and other RECs do not contribute to the city's emissions reduction goals, they can be claimed by consumers wishing to purchase renewable energy and be good stewards of the environment.

5 RESULTS

The impact assessment of the NZAP found quantifiable emissions impacts by the actions that have been taken since 2015, but they are not necessarily fully reflective of the efforts to date. Much of the groundwork has been set for future success through policy planning, design, and regulatory action. The estimated emission impacts from the first five years do indicate, however, that there is still much work to do to meet the city's net zero emissions goals.

Of the five NZAP actions that were identified as likely having had measurable results, the emissions savings could only be calculated for three. For the Custom Retrofit Program, this program has been implemented, but no measurable projects have been completed. For the Cambridge CCA, RECs were not considered qualified impacts and the community solar project has not been constructed. In addition, actual performance data for buildings constructed under the Article-22, Green Building Ordinance in the last five years were not available for this assessment.

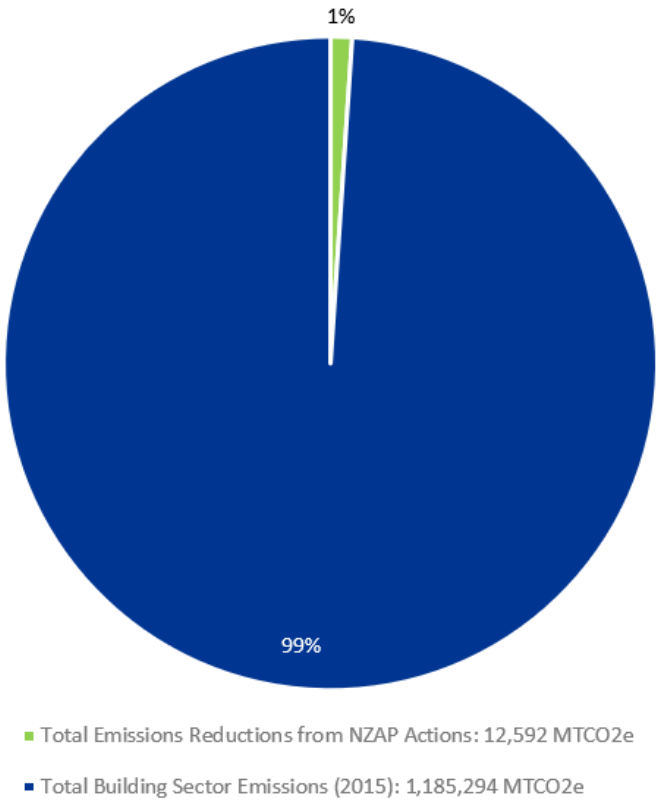
In reviewing these results, the long lead time associated with some of the NZAP actions needs to be considered as it makes it difficult to determine the real quantifiable impacts of the program over the initial five-year period. To mitigate the delays in obtaining project data, it is recommended that a more robust system for reporting and tracking project-level performance data from all actions be put in place for residents, businesses, and program implementers to access, similar to (or an extension of) the platform used for BEUDO. A listing of the metrics needed for properly assessing impacts is included in Appendix A. A more robust system of tracking performance data will require constant oversight and management to ensure that responsible parties are entering the data in a timely manner and correctly. While this may seem like an additional burden on city staff, it will save significant work, time, and money over having to collect performance data only periodically (i.e., every five years) and improve the quality of future impact analyses. Consistent tracking and monitoring of data will also enable the city to more quickly take action and make adjustments if certain actions are not performing as expected.

The emissions associated with the building sector overall in 2015 were 1,185,295 MTCO2e. Through this assessment, the cumulative NZAP emissions savings from 2015-2019 was estimated to be 12,592 MTCO2e as shown in Table 5-1. This represents 1% of the total buildings sector emissions from 2015 (Figure 5-1).

Table 5-1: Summary of Performance by Action

Action	Parameter	Estimated Emissions Savings (MTCO2e)
Customer Retrofit Program (NZAP Action 1.1.1.)	Electricity and Gas Savings from Participating Projects	0
Article 22 Green Building Requirement (NZAP Action 2.3)	Estimated energy savings beyond code	8,705
Renewal of Municipal Buildings (NZAP Action 2.4,2)	Electricity and Gas Savings from Participating Projects	1,504
Rooftop Solar Ready Requirements (NZAP Action 3.2)	Capacity of Installed Systems & System Production	2,383
Cambridge Community Electricity Aggregation – Green+ Product	Purchase of 100% Renewable Electricity consumption	0
	Total	**12,592**

Figure 5-1: Emissions savings from NZAP Action 2015-2019



Further, what this chart does not reflect is that the buildings sector emissions have remained flat in recent years (see Error! **Reference source not found.** provides a comparison of the current trajectory versus the business as usual (BAU) projections and the 1.5°C UNEP target. The current trajectory is shown as the Recent Emissions Trendline in the chart below and was based on the emissions data from 2012-2019. The BAU forecast is the expected emissions forecast into the future from 2015 if no intervention had taken place to curb emissions at the state or local level beyond the electricity emissions savings expected from the

Renewable Portfolio Standard (RPS). This is based on historical population and jobs growth. What is clear is that if the current trends persist, the gap between actual emissions and the reductions needed to meet the UNEP targets will continue to increase, making it more and more difficult to achieve the City's goals for 2030 and beyond.

Figure 2-2). This indicates that any declines that have been achieved have largely been offset by recent economic growth and new construction. Similar to what has been found on the global scale[5], the effects of the actions taken to date are too small to achieve the city's goals.

We expect greater emissions reductions as more impactful actions are implemented, including the low carbon energy supply and BEUDO performance enhancement requirements; however, over the next 10 years, emissions need to be reduced 240,000 – 290,000 MTCO2e just to align with the 2°C Paris Agreement limit—an almost 20x increase over the initial five-year period. The city needs to remain aggressive in its approach and find additional ways to cut greenhouse gas emissions. The next five-year period will be critical. If the current trend continues and emissions remain flat, meeting the targets set by the Paris Agreement for 2030 will become much more difficult, and significant adjustments in strategy will be needed to achieve carbon neutrality by 2050.

[5] See Christensen, J. and Olhoff, A. (2019). Lessons from a decade of emissions gap assessments. United Nations Environment Programme, Nairobi

APPENDIX A – KEY METRICS FOR TRACKING NZAP PERFORMANCE

Action 1.1.1. Custom Retrofit Program	
Data Points (Overall Program Performance)	**Input**
Program Year	[2020]
Projects complete per year	#
Number of new projects enrolled in program	#
Data Points (Individual Projects)	**Input**
Project ID	
Completion Date	Date
Type of project [Lighting = L, HVAC Heating = HH, HVAC Cooling = HC, Custom (Other) = O]	(L, H, O)
Est. gas savings from energy efficiency study	Therms
Est. electricity savings from energy efficiency study	kWh

Action 2.3. Article 22 - Green Building Cert	
Data Point	**Input**
Program Year	[2020]
Number of projects permitted (from Building Permit data)	#
Number of residential projects	#
Number of residential units	#
Number of commercial projects	#
Floor area (commercial only)	Square feet
Number of Platinum Level Cert	#
Number of Gold Level Cert	#
Number of Silver Level Cert	#
Energy performance over baseline	%
Modeled energy consumption (from energy model)	mmBtu
Reference baseline	Standard (e.g. ASHRAE)

Action 2.4.1. Net Zero Requirement for New Const. of Municipal Buildings	
Data Point	**Input**
Project Name	Name
Year Completed	Year
Building Type/Use	Verbose Desc.
Floor area	Square feet
Baseline Energy Performance Estimate (from Energy Model)	mmBtu
Designed Energy performance over baseline	%
Modeled energy consumption (from energy model)	mmBtu
Reference baseline	Standard (e.g. ASHRAE)
Estimated annual emissions	Metric Tons CO2e
Actual gas consumption (monthly according to billing data)	Therms
Actual electricity consumption (monthly according to billing data)	kWh
Renewable energy capacity/production	kW/kWh

Action 2.4.2. Renewal of Municipal Buildings	
Data Points (Overall Program Performance)	**Input**
Program Year	[2020]
Projects complete per year	#
Data Points (Individual Projects)	**Input**
Project ID	
Project Completion Date	Date
Type of project [Lighting = L, HVAC Heating = HH, HVAC Cooling = HC, Custom (Other) = O]	(L, H, O)
Est. gas savings	Therms
Est. electricity savings	kWh
Renewable energy capacity/production	kW/kWh

Action 3. Multi-solar Initiatives	
Data Point (Overall Program)	**Input**
Program Year	[2020]
Number of NC projects completed - Residential	#
Number of NC projects completed - Sm. Commercial	#
Number of NC projects completed - Large Commercial	#
Data Point (Individual Projects)	**Input**
Project ID	
Address	
Project completion date	Date
Type of project (residential, sm. commercial, lg. commercial)	type
System capacity	kW
Modeled system production	kWh

Action 3 (supportive) Cambridge CCA Participation	
Annual Program Data	**Input**
Year	2020
No. of Resi. Accounts Participating	#
No. of Comm. Accounts Participating	#
For each new account, length of time from start to CCA transfer	Months
Total Resi. Consumption	kWh
Total Comm. Consumption	kWh
Total Number of Eversource Resi. Electric Accounts	#
Total Number of Eversource Comm. Electric Accounts	#
Total Resi. Consumption Eversource Accounts	kWh
Total Comm. Consumption Eversource Accounts	kWh
Electricity sales (total)	$
Amount raised from operational adder	$
Data Point (Community Solar)	**Input**
Project ID	
Year completed	year
Cost of construction	$
System capacity	kW or MW
Modeled production	kWh or MWh
Actual production following one year of operation	kWh or MWh

APPENDIX C. PROGRAM TRACKING METRICS

Action	Metric	Unit of Measurement	Data Source
NZAP Action 1.1: Custom Retrofit Program for Residential (<50 Units) and Small Commercial	MF Retrofit Projects Completed	Number	
	SB Retrofit Projects Completed	Number	
	Retrofit Projects Completed	Number	
	Electrification Projects Completed	Number	
	Estimated Electric Savings	kWh	
	Estimated Gas Savings	Therms	
	New MF Projects Enrolled	Number	
	New SB Projects Enrolled	Number	
NZAP Action 1.2: BEUDO Performance Requirements	Buildings Disclosing Energy Use	Number	
	Square Footage of Buildings Disclosing Energy Use	SF	
	BEUDO Portfolio Electricity Consumption	kWh	
	BEUDO Portfolio Gas Consumption	Therms	
	BEUDO Portfolio Emissions	MT GHG	
	Buildings Disclosing Energy Use (all years)	Number	
	Square Footage of Buildings Disclosing Energy Use (all years)	SF	
	BEUDO Portfolio Electricity Consumption (all years)	kWh	
	BEUDO Portfolio Gas Consumption (all years)	Therms	
	BEUDO Portfolio Emissions (all years)	MT GHG	
NZAP Action 1.3: Transaction Points	MF Retrofit Projects Completed	Number	
	SB Retrofit Projects Completed	Number	
	Retrofit Projects Completed	Number	
	Lighting Retrofit Projects Completed	Number	
	HVAC Heating Retrofit Projects Completed	Number	
	HVAC Cooling Retrofit Projects Completed	Number	
	Custom Retrofit Projects Completed	Number	
	Estimated Electric Savings	kWh	
	Estimated Gas Savings	Therms	
	New Projects Enrolled in the Program	Number	
NZAP Action 2.1: Net Zero New Construction	Projects Permitted	Number	
	SF of Residential Projects	SF	
	SF of Commercial Projects	SF	
	Residential Units	Number	
NZAP Action 2.3: Green Building Requirement	Projects Permitted	Number	
	SF of Residential Projects	SF	
	SF of Commercial Projects	SF	

	Residential Units	Number	
	LEED Silver Certifications	Number	
	LEED Gold Certifications	Number	
	LEED Platinum Certifications	Number	
NZAP Action 2.4: Net Zero Requirements for Public Buildings	Retrofit Projects Completed	Number	
	NC projects completed	Number	
	Electric Savings	kWh	
	Estimated Gas Savings	Therms	
	Square Footage of Buildings with Retrofit Project Completed	SF	
NZAP Action 3.1: Low Carbon Thermal	RT Retrofit Projects Completed	Number	
	Estimated Gas Replaced	Therms	
	DE Pilot Projects Engaged	Number	
	Customers in Pilot	Number	
	Anticipated Gas Displacement	Therms	
NZAP Action 3.2: Community Solar Access	Total Solar Installs	Number	
	Total Capacity Installed	kW	
	Residential Solar Installations	Number	
	Small Commercial Solar Installations	Number	
NZAP Action 3.3: Off-site Renewable Energy Access	Participating Residential Electric Accounts	Number	
	Participating Residential Electric Consumption	kWh	
	Participating Commercial Electric Accounts	Number	
	Participating Commercial Electric Consumption	kWh	
	Total emissions avoided (lbs)	lbs	

APPENDIX D. NET ZERO TASK FORCE FEEDBACK

Net Zero Action Plan (NZAP)

Task Force Feedback Summary

Prepared for: The City of Cambridge

Prepared by: DNV Energy Services USA Inc.

Issued: 05/24/2021

1 SUMMARY

The intent of this document is to capture feedback collected from Task Force members about adjustments to the individual proposals in the City of Cambridge's Net Zero Action Plan.

Task force members provided feedback through two separate channels:

- Consider It poll: ranking the priority of each action item, as well as adding comments and pros/cons list for each
- Google Slide deck: using the comments feature

The information within is presented impartially to ensure the feedback from the Task Force members is accurately represented and accounted for. Comments from both feedback channels are shown for each proposal to allow the City of Cambridge to confirm the preferred recommendations for each proposal prior to the final meeting of the Task Force members on May 27 2021.

2 CONSIDER IT: PRIORITY RANKINGS

The Consider It poll was used to gain consensus on the priority of each adjusted action item. The results from the Poll are shown below:

NZAP Action Item		Votes by priority percentage														Total Votes	Average Priority	Priority Ranking	Comments
		1	2	3	4	5	6	7	8	9	10	11	12	13	14				
1.1	Custom Retrofit Program for Residential (up to 50 units) and Small Commercial	-66	-50	-32	-32	-2	0	25	68	75	75					10	6.10	12	*total excludes poll creator (john)
1.2	BEUDO Requirements	52	57	69	75	78	82	86	89	91	100	100				11	79.91	1	*total excludes poll creator (john)
1.3	Transaction Points Upgrade Requirements	10	10	22	33	49	75	75								7	39.14	8	
1.4	Financing and Capacity Building (New Action)	-18	0	17	35	36	59	60	62	75						9	36.22	9	
2.1	Create Net Zero Targets for New Construction	50	59	62	64	66	70	80	83	89	90					10	71.30	2	*total excludes poll creator (john)
2.3	Increase Green Building Requirements in Cambridge Zoning Ordinance	-64	-19	17	25	36	41	75	90	92						9	32.56	10	*total excludes poll creator (john)
2.5	Embodied Carbon (New Action)	-81	-15	-2	19	22	31	34	50	52	54	80	84			12	27.33	11	*total excludes poll creator (john)
3.1	Carbon-free Thermal Energy	10	29	29	29	30	43	54	70	73	89					10	45.60	7	*total excludes poll creator (john)
3.2.1	Rooftop Solar Requirement	0	19	23	26	29	44	50	60	92	100	100				11	49.36	6	
3.2.2	On-site Renewable Energy Access	0	29	50	66	68	72	80	94	100						9	62.11	4	
3.3	Off-site Renewable Energy Access	0	23	38	43	50	53	73	73	93	94					10	54.00	5	
4	Cambridge Community Energy Program (Aggregation 3.0- NEW)	39	40	50	56	57	72	73	90	100						9	64.11	3	

The following conclusions can be drawn from the polling exercise:

1. The following NZAP action items are the highest priority for the Task Force (in ranking order)
    a. BEUDO Requirements
    b. Creating Net Zero targets for New Construction
    c. Cambridge Community Energy Program Aggregation 3.0
2. The following NZAP action items are the lowest priority for the Task Force (in ranking order)
    a. Custom Retrofit Program for Residential and Small Commercial
    b. Embodied Carbon
    c. Increasing Green Building Requirements in Cambridge Zoning Ordinance

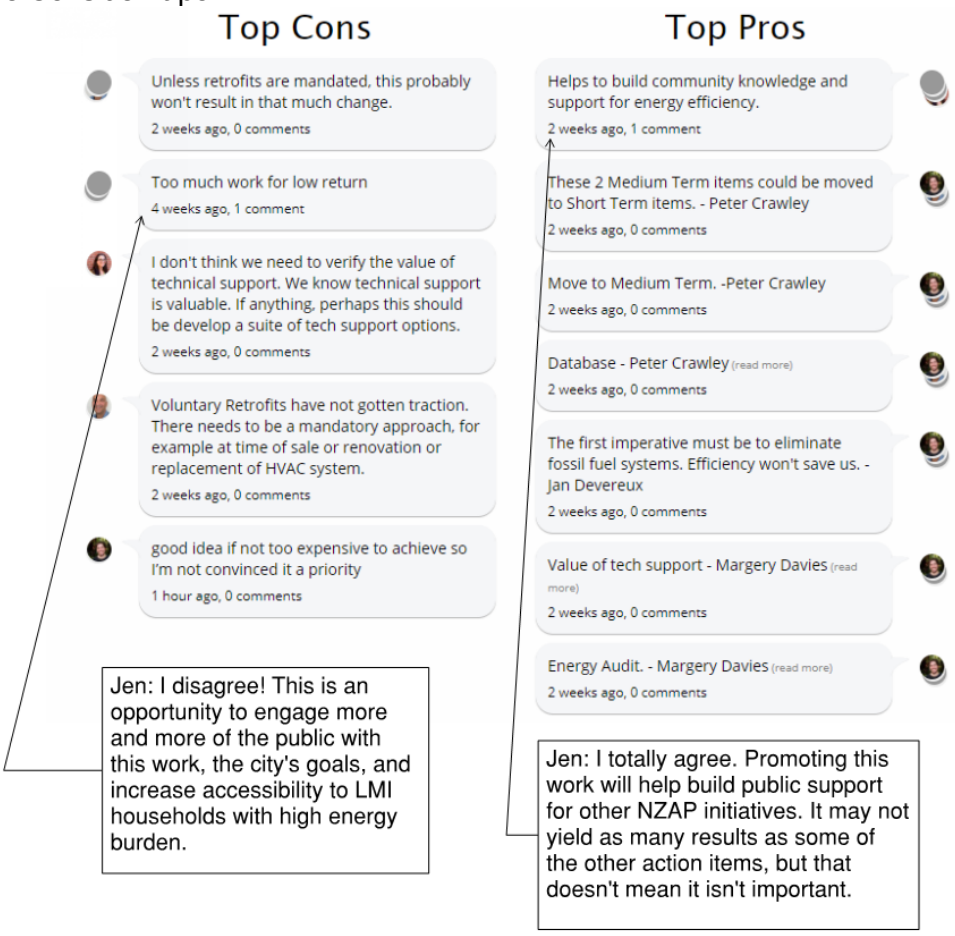
3 COMMENTS: CONSIDER IT POLL

The following pages are used to summarize the comments and priority ranking of each revised NZAP Action item presented in the Consider It poll

1.1 Custom Retrofit Program for Residential (up to 50 units) & Small Commercial

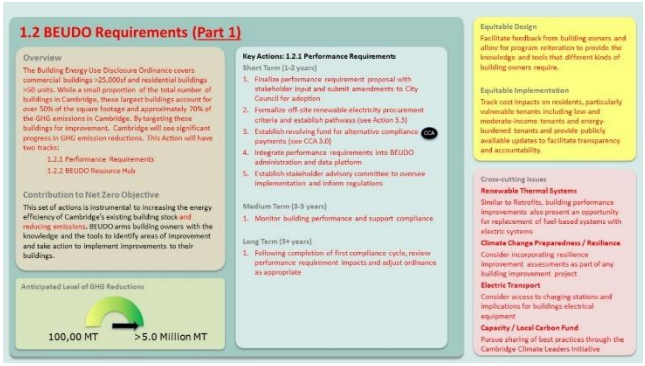
- Number of Opinions logged: 10
- Poll Priority Ranking: 12/12
- Average Priority score: 6.10
- Key takeaways
    - The lowest priority for the task force
    - Timelines for long and medium action items should be accelerated

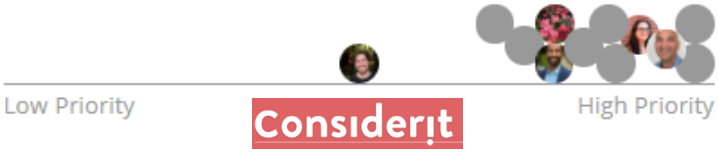
Comments in the Consider It poll:



1.2 BEUDO Requirements

- Number of Opinions logged: 11
- Poll Priority Ranking: 1/12
- Average Priority score: 79.91
- Key takeaways:
    - The highest priority for the task force
    - Alternative pathways for implementation should be considered





Comments in the Consider It poll:

Top Cons

Agreed that an ACP that approximates the cost/effort to improve the building's performance will be needed to avoid owners to defaulting to payments for non-compliance.
2 weeks ago, 0 comments

This is absolutely a high priority, but I don't see anything addressing my previous comment about giving teeth to the ACP mechanism.
2 weeks ago, 0 comments

In terms of equity, I'd love to see lang that allocates some portion of ACP $ to bldgs that might struggle to be in compliance.
2 weeks ago, 0 comments

Top Pros

VERY Important: large buildings are the biggest source of GHG emissions in Cambridge.
2 weeks ago, 0 comments

Fast-track development of BEAUDO Performance Requirements - Peter Crawley (read more)
2 weeks ago, 0 comments

Need to refine our measurement and reporting, must do it WITH property owners!
4 weeks ago, 0 comments

Alternative Compliance Payment Structure - David Adamian (read more)
2 weeks ago, 0 comments

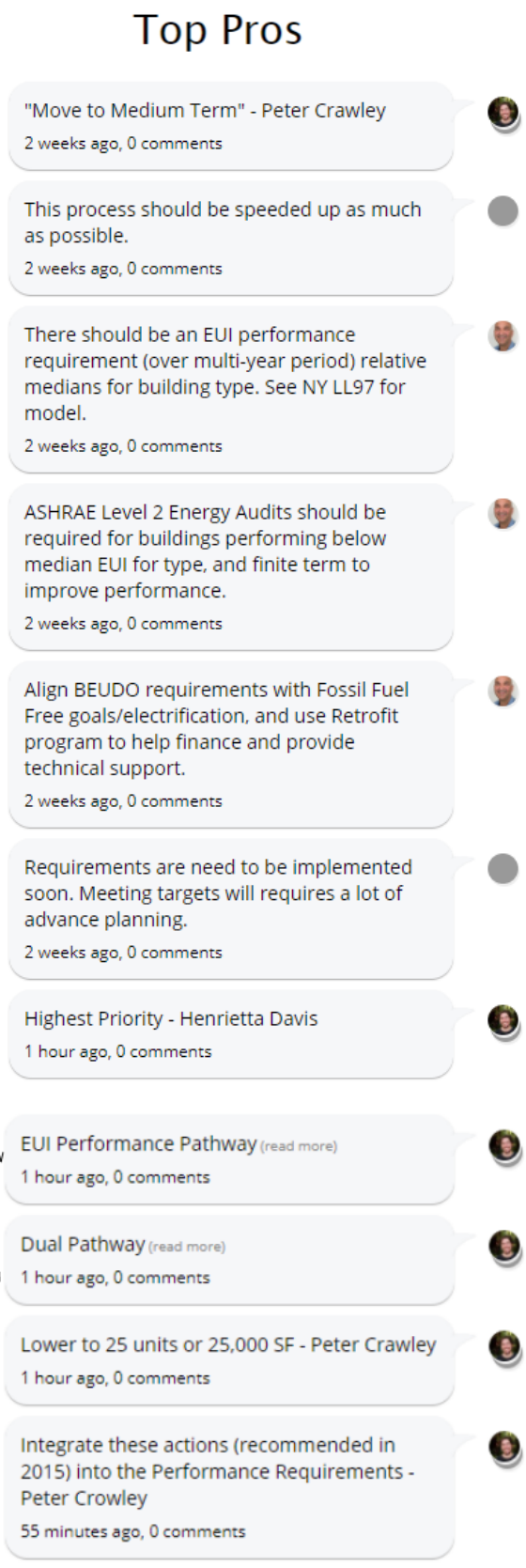
Reduce BEUDIO Threshold. - Peter Crawley (read more)
2 weeks ago, 1 comment

Cambridge Apt buildings with 25 units typically have professional management and are part of a portfolio of buildings. They should conform to BEUDO regs.

1.2 BEUDO Requirements (con't)

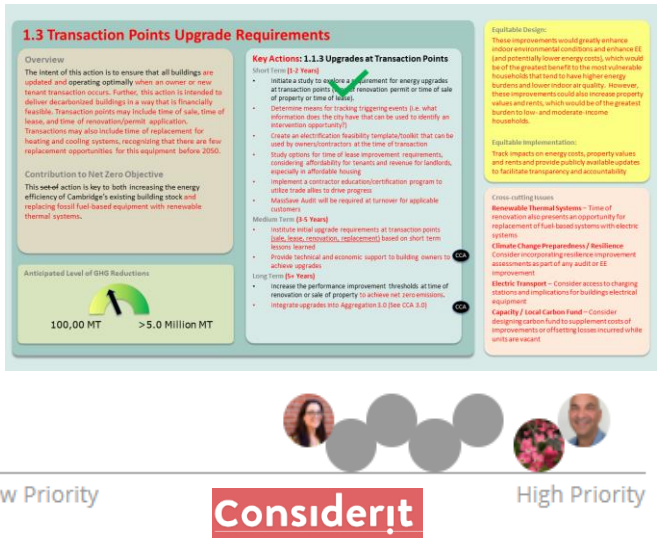
Yes, there needs to be an Energy Efficiency EUI performance requirement/pathway, using Energy Star PM benchmarking where applicable. For example, requirement that all buildings below the median EUI must improve performance to sector median within x years. This assures that Absolute emissions are reduced and retrofits to buildings are incentivized. (The acceptable EUI thresholds should increase over time.) For buildings such as labs not included in Energy Star PM, an alternative set of EUI standards for Cambridge labs should be established using BEUDO data and third-party data, such as Labs21. The Energy Efficiency pathway should be coupled with a Net Zero Emissions pathway that incentivizes the electrification/decarbonization of buildings and investment in on-site and off-site renewable energy, including entering PPAs, Green Tariff programs, Community Aggregations, etc. The quality of the programs, and the RECs (and Offsets) accompanying them, need to be high-quality and meet City established criteria (for additionality, 3rd-party certification, etc.).- Peter Crawley.

The BEUDO Performance Requirements subcommittee can develop the Dual-Pathway, phased program and include penalties for non-compliance - such as a payment for MTCO2e GHGs below compliance levels (like NY's Local Law 97 program). The details of thresholds, timelines, penalties, reporting, alternative compliance, funding, technical support, etc. would need to be worked-out. Cambridge can model Performance Requirements after programs in other cities, like NY, Seattle, San Fran, DC. - Peter Crowley

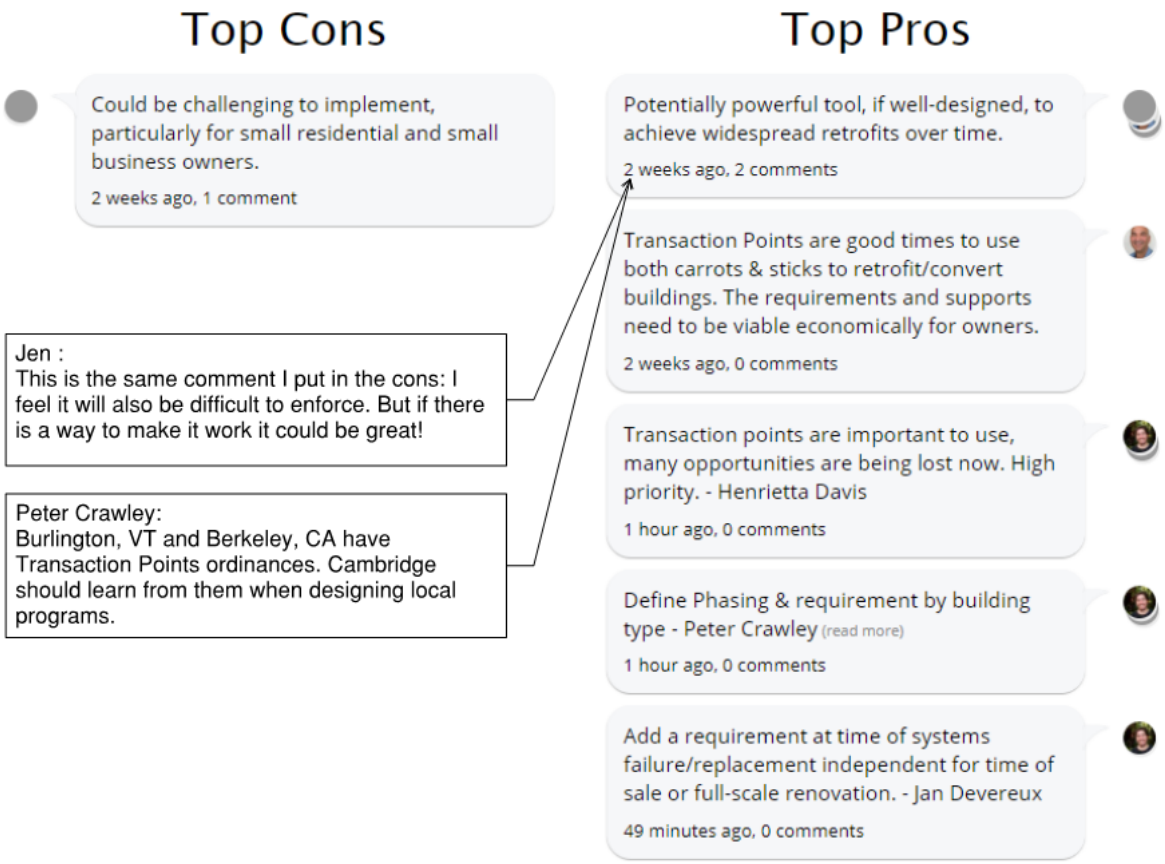


1.3 Transaction Points Upgrade Requirements

- Number of Opinions logged: 7
- Poll Priority Ranking: 8/12
- Average Priority score: 29.14
- Key takeaways
    - Low Priority for the task force
    - Enforcement of this action is critical for success
    - More detail is needed for the implementation of this action

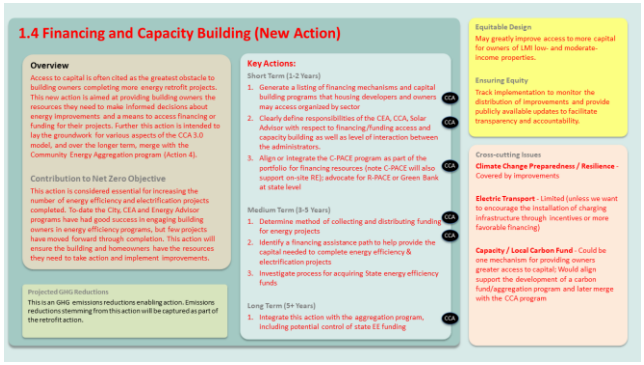


Comments in the Consider It poll:

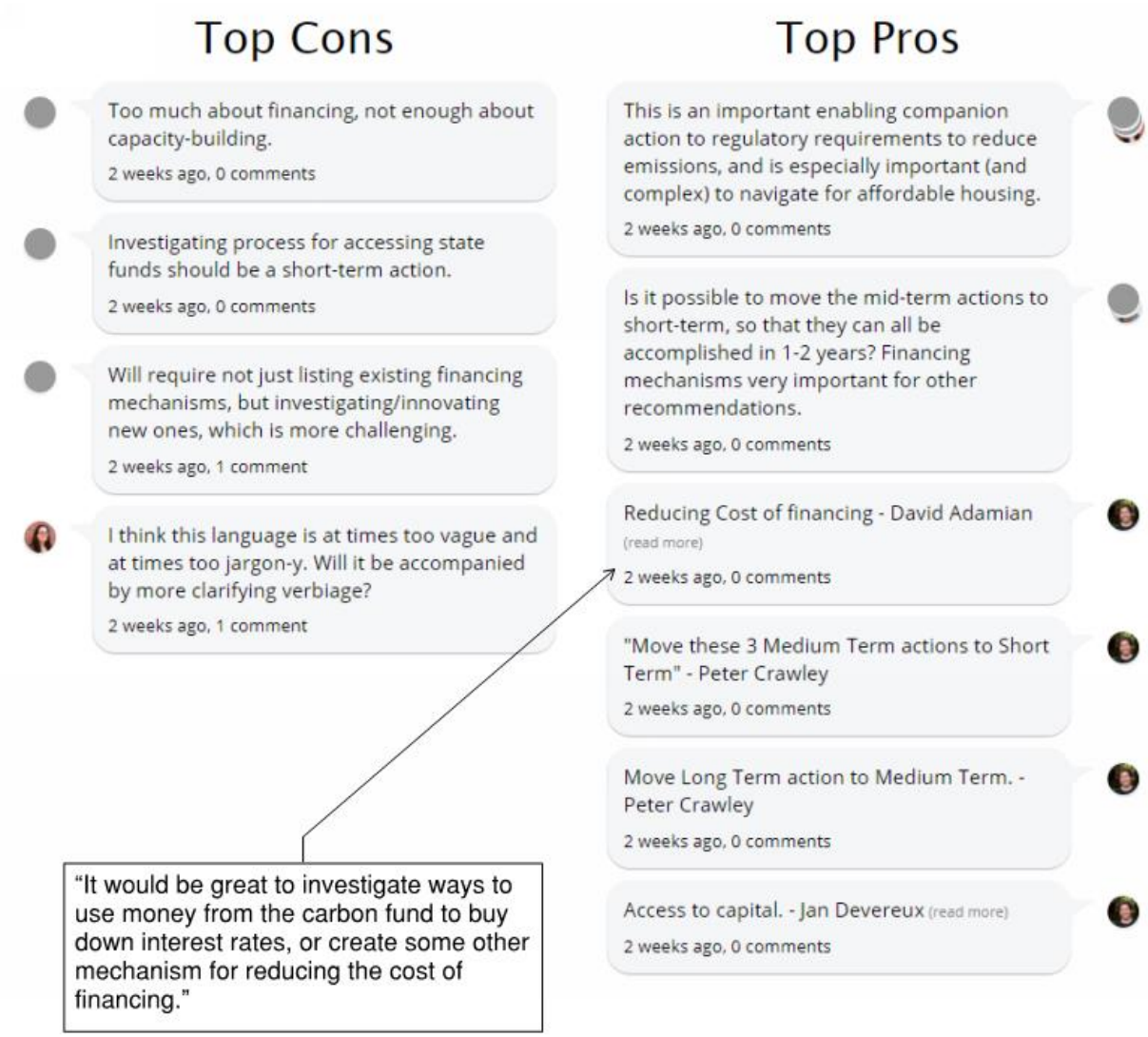


1.4 Financing and Capacity Building (New Action)

- Number of Opinions logged: 9
- Poll Priority Ranking: 9/12
- Average Priority score: 36.22
- Key Takeaways
    - Low priority for the task force
    - Accelerate the timeline for medium- and long-term action items



Comments in the Consider It poll:



2.1 Create Net Zero Targets for New Construction

- Number of Opinions logged: 10
- Poll Priority Ranking: 2/12
- Average Priority score: 71.30
- Key takeaways
    - Very high priority for the task force
    - Action items should be aligned with state level NZ policy

Comments in the Consider It poll:

Top Cons

Top Pros

"Doesn't the new state stretch code give us NZ ability in 18 months? Can't we move faster? - Jan Devereux

2 weeks ago, 0 comments

Accelerate the timeline for this recommendation.

2 weeks ago, 0 comments

This seems like low hanging fruit, but would add in provisions to allow for more flexible timeline if state policy changes sooner.

2 weeks ago, 0 comments

“How should this state-level advocacy take place?” -Margery Davies

2 weeks ago, 0 comments

Is the re-evaluation of the timeline at 3-5 years necessary? Opens the door to delays.

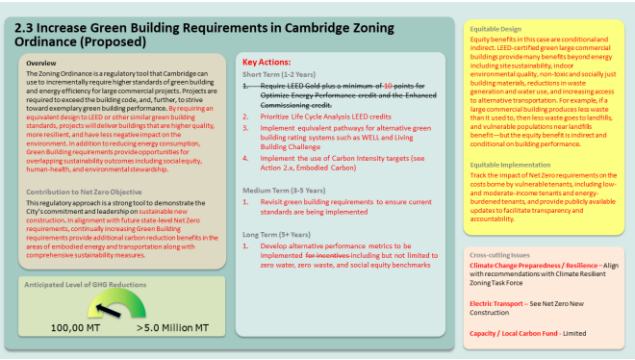
2 weeks ago, 1 comment

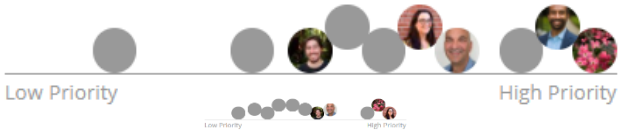
highest priority with a few exceptions if absolutely necessary - Henrietta Davis

1 hour ago, 0 comments

2.3 Increase Green Building Requirements in Cambridge Zoning Ordinance

- Number of Opinions logged: 9
- Poll Priority Ranking: 10/12
- Average Priority score: 32.56
- Key takeaways:
  - Low Priority for the task force
  - Consider alternative green building rating systems or performance metrics





Comments in the Consider It poll:

Top Cons

I think the focus should be on NZ construction. Captured elsewhere.
2 weeks ago, 0 comments

Would like to see the long term item moved to medium term.
2 weeks ago, 0 comments

Add Passive House to bullet #1 (read more)
2 weeks ago, 0 comments

Top Pros

"Why should these be "alternative" performance metrics, instead of "additional" performance metrics?" - Margery Davies
2 weeks ago, 0 comments

"Why wait three years to see if the green building standards are being implemented? Shouldn't the implementation of standards happen as soon as those standards are adopted? -MD
2 weeks ago, 0 comments

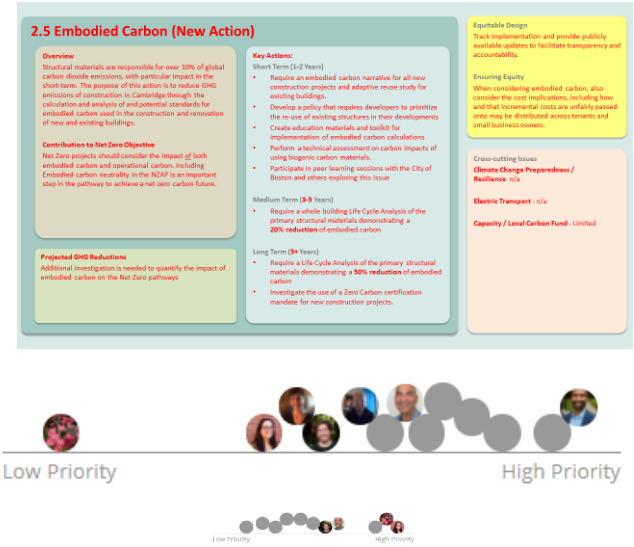
"WELL is not an energy efficiency or emissions-oriented certification; it's a health & wellness certification. Mixing apples & oranges will cause confusion." - Peter Crawley
2 weeks ago, 1 comment

Of course! Highest priority - Henrietta Davis
1 hour ago, 0 comments

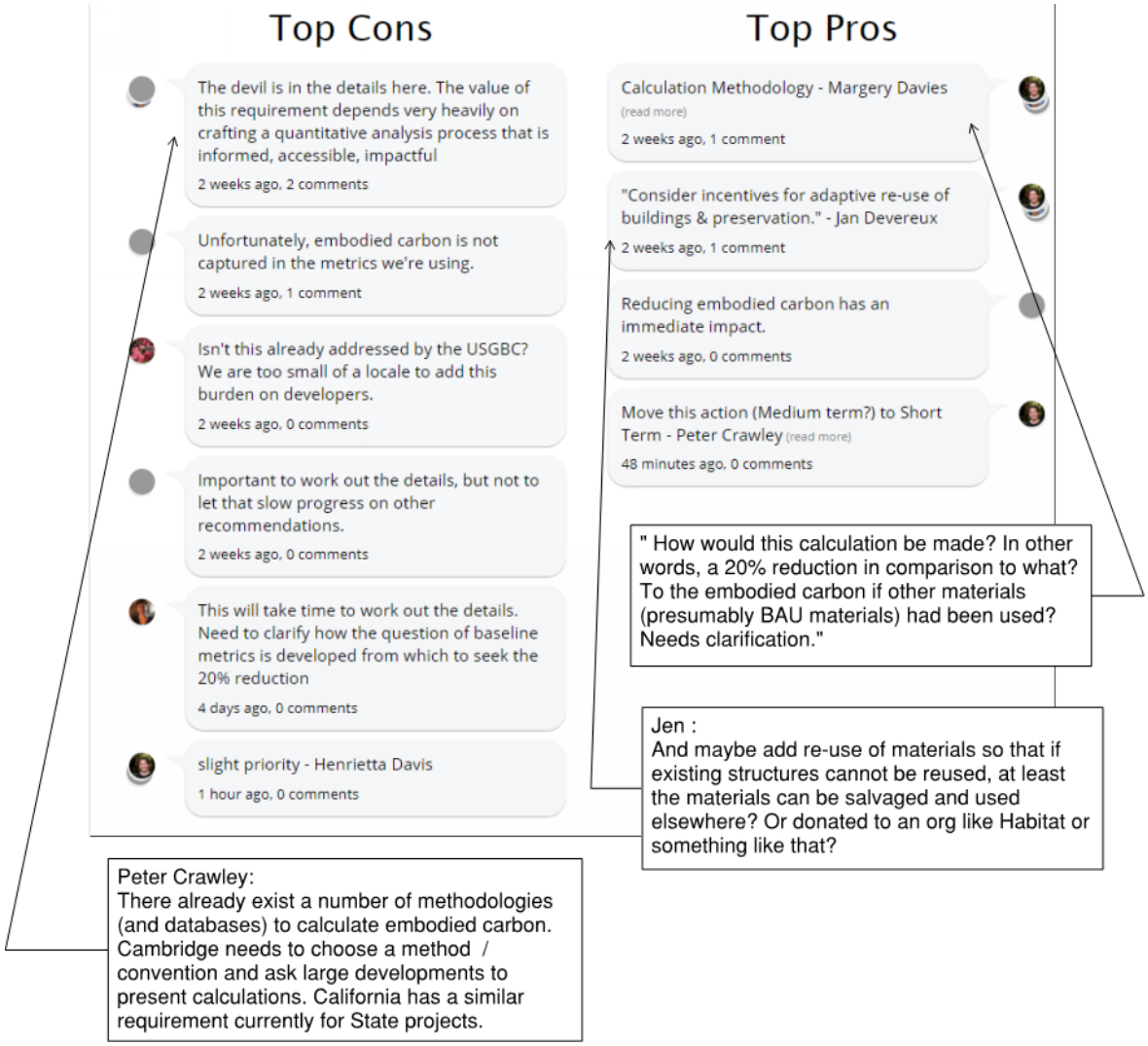
An alternative Green Rating System should include Enterprise Green Communities for multi family , Passive House and another health/wellness criteria is Fitwell. - Jane Carbone
just now, 0 comments

2.5 Embodied Carbon (New Action)

- Number of Opinions logged: 12
- Poll Priority Ranking: 11/12
- Average Priority score: 27.33
- Key Takeaways
    - Very low priority for task force
    - Confirm the methodology for carbon accounting

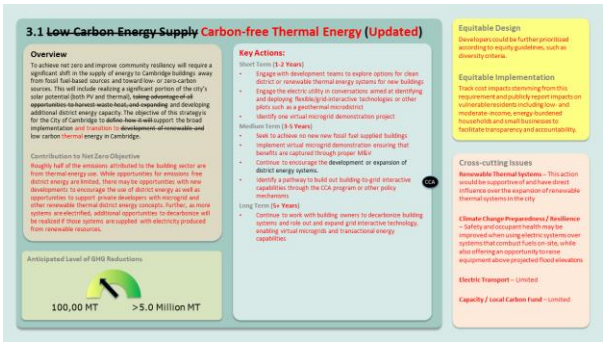


Comments in the Consider It poll:

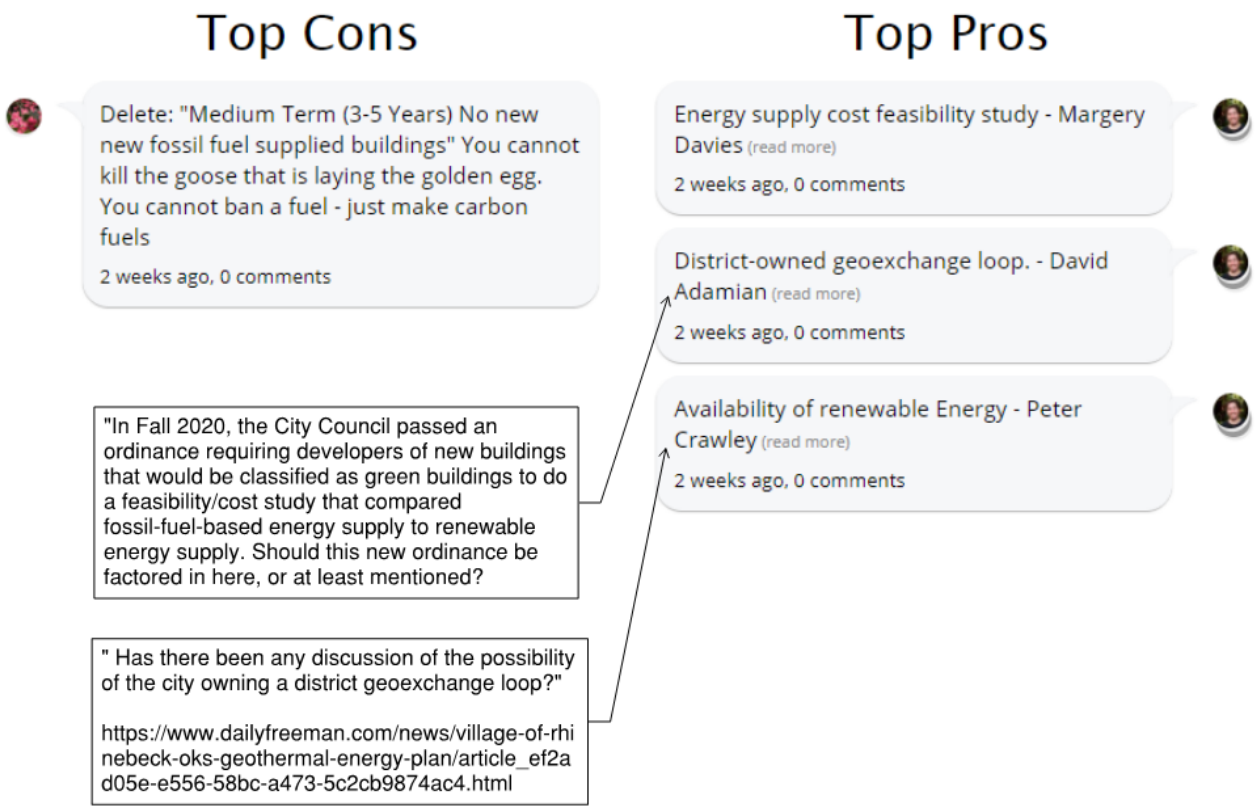


3.1 Carbon-free Thermal Energy

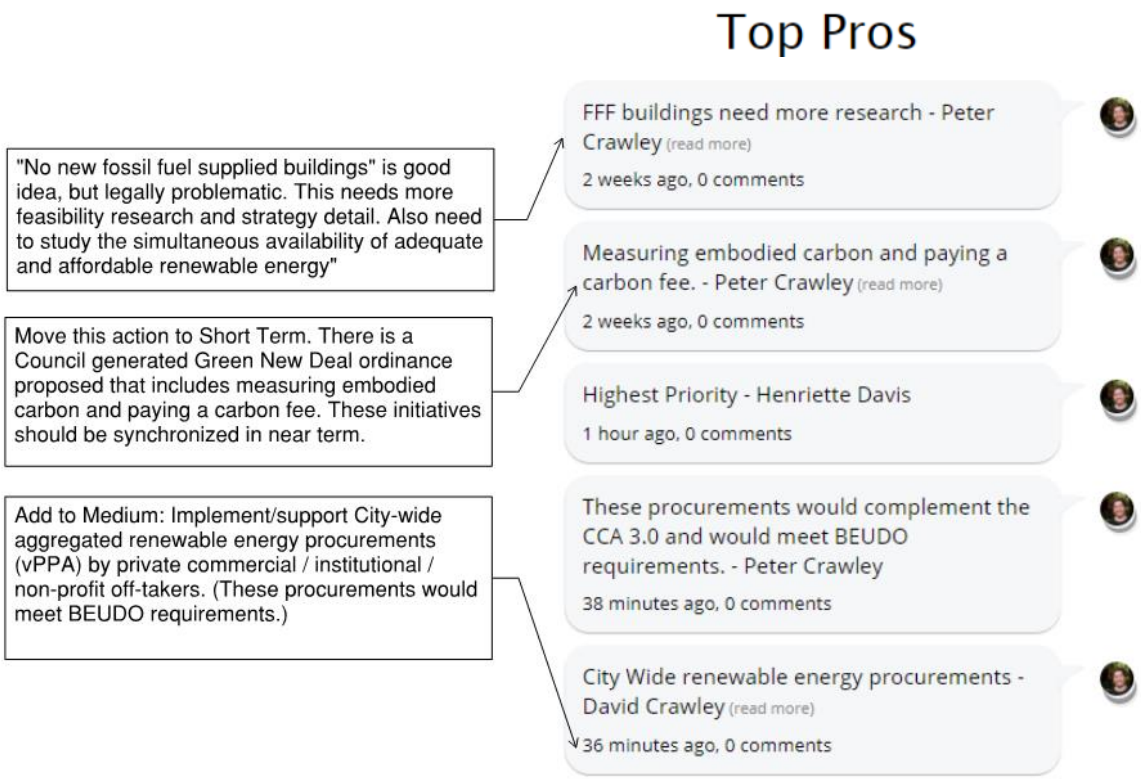
- Number of Opinions logged: 10
- Poll Priority Ranking: 7/12
- Average Priority score: 45.60
- Summary of comments:
    - Low Priority by the task force
    - Consider requesting feasibility studies for fuel switching or district energy solution
    - Add pathways for a Carbon Fee or VPPA



Comments in the Consider It poll:

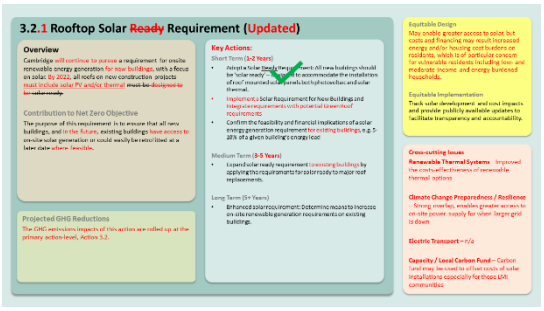


3.1 Carbon Free Thermal Energy (Con't)



3.2.1 Rooftop Solar Requirement

- Number of Opinions logged: 11
- Poll Priority Ranking: 6/12
- Average Priority score: 49.36
- Summary of comments:
    - Medium priority by the task force
    - Align action requirements with green roofs requirements
    - Define requirements more clearly



Comments in the Consider It poll:

Top Cons

Without storage risk a mismatch of generation and demand
2 weeks ago, 0 comments

Need clarity about how much electricity solar energy systems would generate.
2 weeks ago, 0 comments

Add exception for homes where solar won't be feasible bc of insufficient exposure. Include lang for all roofs being high albedo.
2 weeks ago, 0 comments

Top Pros

Cambridge City Council has passed a Green Roofs requirement on May 3; goes into effect June 1,2021.
2 weeks ago, 0 comments

Encourage bio-solar option (planted + solar) as well as solar only
3 weeks ago, 0 comments

Massachusetts already passed solar ready requirement (for new buildings?)
2 weeks ago, 0 comments

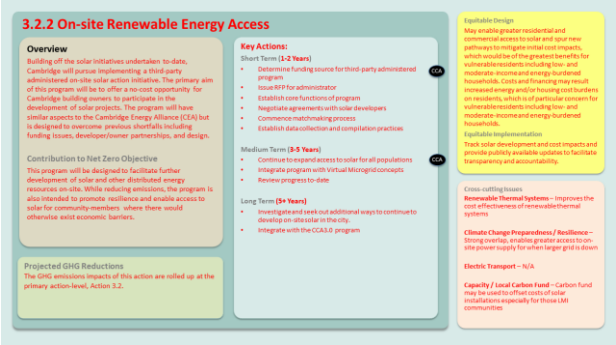
Move from "Solar Ready" to "Solar Installed & Operating" for all buildings covered under Solar Ready requirement - which is broader population than recent Council green roof ordin.
2 weeks ago, 0 comments

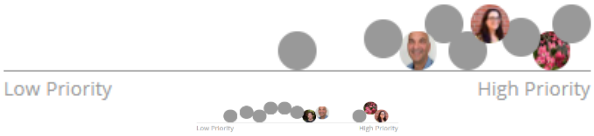
I am absolutely for a solar requirement. Is this still possible with green roof ordinance? - Henrietta Davis
1 hour ago, 0 comments

Green Roofs + Solar Panels - Margery Davis
(read more)
16 minutes ago, 0 comments

3.2.2 On-site Renewable Energy Access

- Number of Opinions logged: 9
- Poll Priority Ranking: 4/12
- Average Priority score: 62.11
- Summary of comments:
    - High priority by the task force
    - Provide alternative project-type-specific pathways for implementation
    - Consider solar + storage as a package





Comments in the Consider It poll:

Top Cons

On site renewables are important, but would love to see battery pairing addressed here.
2 weeks ago, 0 comments

Top Pros

Could be paired with solar requirement to give building owners the option of leasing roof space for community solar capacity
2 weeks ago, 0 comments

"There is a good deal of information on the web about integrating green roofs with solar panels -- biosolar roofs." - Margery Davies
2 weeks ago, 0 comments

We have come far in 20 years; we have so much more to go.
2 weeks ago, 0 comments

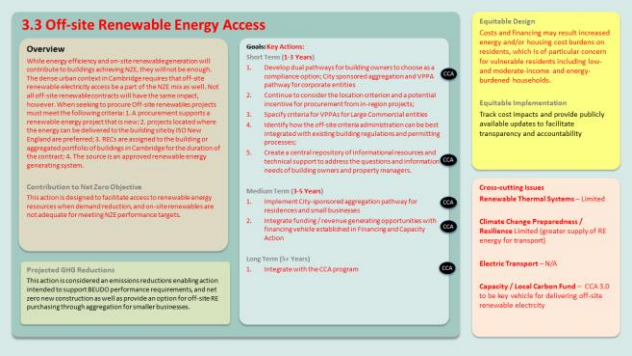
Massachusetts has passed a solar ready requirement.
2 weeks ago, 0 comments

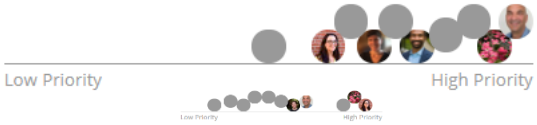
Cambridge City Council passed a Green Roofs ordinance on May 3, to go into effect June 1, 2021.
2 weeks ago, 0 comments

High Priority, good idea - Henrietta Davis
1 hour ago, 0 comments

3.3 Off-site Renewable Energy Access

- Number of Opinions logged: 10
- Poll Priority Ranking: 5/12
- Average Priority score: 54.00
- Summary of comments:
    - Medium priority for the task force
    - Accelerate the timeline for medium-term actions
    - Coordinate pathways for private off-takers





Comments in the Consider It poll:

Top Cons

Make sure preference for New England-based solar energy does not encourage destruction of forests/trees.
2 weeks ago, 1 comment

Top Pros

Important companion piece to existing building performance requirements as most large buildings will not be able to meet emissions targets without offsite procurement.
2 weeks ago, 0 comments

Medium-term recommendations should be speeded up as much as possible.
2 weeks ago, 0 comments

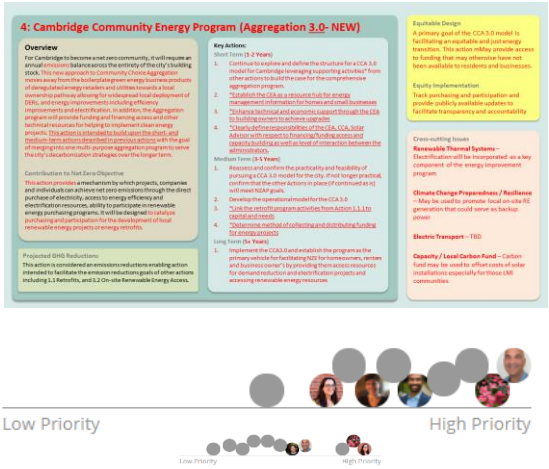
Adequate off-site renewable energy for large off-takers is essential until utilities green electricity supply under State mandate by 2050. Large private aggregations necessary.
2 weeks ago, 1 comment

Large offshore wind turbines would be wonderful
2 weeks ago, 0 comments

I agree with Peter C.
2 weeks ago, 0 comments

Highest priority - Henrietta Davis
1 hour ago, 0 comments

4.0 Cambridge Community Energy Program (Aggregation 3.0- NEW)



- Number of Opinions logged: 9
- Poll Priority Ranking: 3/12
- Average Priority score: 64.11
- Summary of comments:
    - High priority for the task force
    - Accelerate the timeline for medium-term actions
    - Make this mandatory with exception pathways for non-compliant projects.

Comments in the Consider It poll:

Top Cons

This language isn't very clear: Link the retrofit program activities from Action 1.1.1 to capital and needs

2 weeks ago, 0 comments

Top Pros

Why does the planning for this need to take so long? Can the Development of the CCA 3.0 model be moved to Short-term?

2 weeks ago, 0 comments

make 100% renewable opt-out rather than opt-in

3 weeks ago, 0 comments

Move implementation of CCA 3.0 model to medium-term, 3-5 years.

2 weeks ago, 0 comments

"If the statute stipulates that aggregation programs should be "opt out," then why is the current Cambridge Community Electricity Program (CEP) "opt in"?" - Margery Davies

2 weeks ago, 0 comments

Engagement with community members through CEA and the CCA will not only benefit them but also build awareness and support of the City's efforts.

2 weeks ago, 0 comments

4 COMMENTS: GOOGLE SLIDE DECK

The following comments have been extracted from the Google Slides file NZAP_Adj Proposals_All 3-30-21_update shared with the Task Force in April 2021. Language below shown with highlighted text has been integrated into the Consider it poll

Overarching Comments:

- Margery Davies
  - The Massachusetts Legislature just passed, and Governor Baker signed into law, S.9 (192nd) "An Act Creating a Next-Generation Roadmap for Massachusetts Climate Policy." To what extent should the provisions of this important law have an effect on the Cambridge NZAP? For example, the law states that "The interim 2030 state-wide greenhouse gas emissions limit shall be at least 50 per cent below the 1990 level, and the interim 2040 state-wide greenhouse gas emissions limit shall be at least 75 per cent below the 1990 level." Should we take these limits as applying to Cambridge? And if so, should the NZAP make specific reference to the limits and how we plan to achieve them? A place to start might be to state the 1990 emissions level, the up to date as possible current emissions level, and how the steps in the NZAP will get us to the goal of 50 per cent below the 1990 level by 2030.
  - It does not make sense to me for us not to refer to S.9, since it is such an important law that sets a number of frameworks within which Cambridge will be operating. At places in the NZAP where S.9 has bearing on the issue being discussed, the appropriate provision of S.9 should be referenced.
- Peter Crowley
  - As a general comment, CPAC found that many Action Items noted as Medium & Long Term needed to be moved-up by at least one category. NZAP is in its 6th year and actions need to occur sooner (within 2 years) rather than later to meet carbon reduction goals.

Slide 2 – Overarching Adjustments (1 comment)

- Margery Davies
  - The Massachusetts Legislature just passed, and Governor Baker signed into law, S.9 (192nd) "An Act Creating a Next-Generation Roadmap for Massachusetts Climate Policy." To what extent should the provisions of this important law have an effect on the Cambridge NZAP? For example, the law states that "The interim 2030 state-wide greenhouse gas emissions limit shall be at least 50 per cent below the 1990 level, and the interim 2040 state-wide greenhouse gas emissions limit shall be at least 75 per cent below the 1990 level." Should we take these limits as applying to Cambridge? And if so, should the NZAP make specific reference to the limits and how we plan to achieve them? A place to start might be to state the 1990 emissions level, the up to date as possible current emissions level, and how the steps in the NZAP will get us to the goal of 50 per cent below the 1990 level by 2030.
  - It does not make sense to me for us not to refer to S.9, since it is such an important law that sets a number of frameworks within which Cambridge will be operating. At places in the NZAP where S.9 has bearing on the issue being discussed, the appropriate provision of S.9 should be referenced.

- Peter Crowley
  - As a general comment, CPAC found that many Action Items noted as Medium & Long Term needed to be moved-up by at least one category. NZAP is in its 6th year and

actions need to occur sooner (within 2 years) rather than later to meet carbon reduction goals.

Slide 6 – 1.1 Custom Retrofit Program for Residential (up to 50 units) and Small Commercial (4 comments)

- Margery Davies
  - "Why do we need to verify the value of technical support here? The technical support for advising on retrofits in large multi-family buildings seems to have already been demonstrated."
  - *"Is an energy audit already required for any renovation building permit? If it is not, develop a policy order to submit to the City Council to require same. This would at least alert the parties applying for a building permit of the possibilities for energy conservation, electrification opportunities, and resilience improvement connected to their proposed renovation."* **–** *Comment was removed from Google Slides*
- Peter Crawley
  - "These 2 Medium Term items could be moved to Short Term items."
  - "Move to (long term) Medium Term"
- Jan Devereux
  - The first imperative must be to eliminate fossil fuel systems. Efficiency won't save us.

Slide 7 – 1.1.2 Additional BEUDO Requirements (Original Slide) (1 comment)

- Peter Crowley
  - Integrate these actions (recommended in 2015) into the Performance Requirements

Slide 8 – 1.2 BEUDO Requirements (Part 1) (4 comments)

- David Adamian
  - "Need to ensure that the performance requirement proposal includes an alternative compliance payment structure that has real teeth and is fair to building owners who have already invested in efficiency (i.e. requirements should be based on absolute performance rather than performance relative to a base year)."
- Peter Crowley
  - Reduce BEUDO threshold for MF Residential to 25 units (or 25,000 SF) to capture more commercial buildings. This size threshold is consistent w/other Cities with EE mandates, such as New York & Wash DC.
  - To fast-track development of BEUDO Performance Requirements and stakeholder review, by establishing subcommittee of current NZAP Working Group and commence immediately with 60-day deadline to integrate results into NZAP and present to Council. BEUDO buildings represent 70% of City GHGs, so core to achieving NZAP goals.
  - Yes, there needs to be an Energy Efficiency EUI performance requirement/pathway, using Energy Star PM benchmarking where applicable. For example, requirement that all buildings below the median EUI must improve performance to sector median within x years. This assures that Absolute emissions are reduced and retrofits to buildings are incentivized. (The acceptable EUI thresholds should increase over time.) For buildings such as labs not included in Energy Star PM, an alternative set of EUI standards for Cambridge labs should be established using BEUDO data and third-party data, such as Labs21.
    The Energy Efficiency pathway should be coupled with a Net Zero Emissions pathway that incentivizes the electrification/decarbonization of buildings and investment in on-

site and off-site renewable energy, including entering PPAs, Green Tariff programs, Community Aggregations, etc. The quality of the programs, and the RECs (and Offsets) accompanying them, need to be high-quality and meet City established criteria (for additionality, 3rd-party certification, etc.).
    - The BEUDO Performance Requirements subcommittee can develop the Dual-Pathway, phased program and include penalties for non-compliance - such as a payment for MTCO2e GHGs below compliance levels (like NY's Local Law 97 program). The details of thresholds, timelines, penalties, reporting, alternative compliance, funding, technical support, etc. would need to be worked-out. Cambridge can model Performance Requirements after programs in other cities, like NY, Seattle, San Fran, DC.

Slide 9 – 1.2 BEUDO Requirements (Part 2)

- Peter Crowley
    - Move to Medium Term
    - Per above, lower to 25 units or 25,000 SF

Slide 10- 1.1.3 Upgrades at Time of Renovation or Sale (original)

- Jan Devereux
    - add a requirement at time of systems failure/replacement independent for time of sale or full-scale renovation.

Slide 11 – 1.3: Transaction Points Upgrade Requirements

- Peter Crawley
    - Need to better define phasing of requirements and specific upgrades being required for various building types. For example: conversion of HW & HVAC to electric; insulation, window replacements, conversion to LED lighting, etc. There needs to be limits on required spending as % of transaction amount and/or allow phasing.

Slide 12 - 1.x Financing and Capacity Building (Proposed New)

- David Adamian
    - “It would be great to investigate ways to use money from the carbon fund to buy down interest rates, or create some other mechanism for reducing the cost of financing.”
- Peter Crawley
    - Move these 3 Medium Term actions to Short Term
    - Move Long Term action to Medium Term

- Jan Devereux
    - Owners other than LMI will need access to capital to replace fossil fuel systems on a more urgent basis; focus on funding that, more bang for the buck than on funding greater efficiency of fossil fuel systems

Slide 16 - 2.1 Create Net Zero Targets for New Construction (Updated)

- Margery Davies
    - “How should this state-level advocacy take place?”
- Jan Devereux

- Doesn't the new state stretch code give us NZ ability in 18 mos? Can't we move faster?

Slide 18 – 2.2 Net Zero Incentives (Updated) ** Not included in Consider It poll*

- *Margery Davies*
  - *Why would incentives be eliminated for commercial and institutional projects? – Comment was removed from Google Slides*
- Jan Devereux
  - If incentives are necessary, they should be front loaded (NZ within 3 years) and scaled back in each year after until the mandate is in place

Slide 20 - 2.3 Increase Green Building Requirements in Cambridge Zoning Ordinance (Proposed)

- Margery Davies
  - Why wait three years to see if the green building standards are being implemented? Shouldn't the implementation of standards happen as soon as those standards are adopted?
  - Why should these be "alternative" performance metrics, instead of "additional" performance metrics?

Slide 22 – 2.4 Net Zero Requirement for New Construction + Deep Retrofits of Public Buildings * *Not included in Consider It poll*

- David Adamian
  - 2.4.1 is “critically important!”

Slide 25 – 2.X Embodied Carbon (New Action)

- Margery Davies
  - *How would this calculation be made? In other words, a 20% reduction in comparison to what? To the embodied carbon if other materials (presumably BAU materials) had been used? Needs clarification. – Comment has been removed from Google Slides*
- Peter Crawley
  - Move this action (Medium term?) to Short Term. There is a Council generated Green New Deal ordinance proposed that includes measuring embodied carbon and paying a carbon fee. These initiatives should be synchronized in near term.
  - Move from Long Term to Medium
- Jan Devereux
  - consider incentives for adaptive re-use of buildings & preservation

Slide 29 – 3.1 Low Carbon Energy Supply (Updated)

- Margery Davies
  - In Fall 2020, the City Council passed an ordinance requiring developers of new buildings that would be classified as green buildings to do a feasibility/cost study that compared fossil-fuel-based energy supply to renewable energy supply. Should this new ordinance be factored in here, or at least mentioned?
    - Cambridge City Council Meeting 2020-11-16
    - Ordinance amendment in yellow below approved, to be ordained 2020-11-2

- Current Zoning Ordinance at https://library.municode.com/ma/cambridge/codes/zoning_ordinance?nodeId=ZONING_ORDINANCE_ART22.000SUDEDE
- Green Energy Analysis Zoning Petition – Substitute Zoning Text
- Shown as Amendment to Current Section 22.25.1 of the Zoning Ordinance, Paragraph (c)
- https://library.municode.com/ma/cambridge/codes/zoning_ordinance?nodeId=ZONING_ORDINANCE_ART22.000SUDEDE

- David Adamian
  - Has there been any discussion of the possibility of the city owning a district geoexchange loop? https://www.dailyfreeman.com/news/village-of-rhinebeck-oks-geothermal-energy-plan/article_ef2ad05e-e556-58bc-a473-5c2cb9874ac4.html
- Peter Crawley
  - Add: City to convene stakeholder group to map feasibility of multiple large (100+ MGW) City-wide aggregated renewable energy procurements (vPPA) by private commercial/institutional/non-profit off-takers.
  - These procurements would complement the CCA 3.0 and would meet BEUDO requirements.
  - Add to Medium: Implement/support City-wide aggregated renewable energy procurements (vPPA) by private commercial/institutional/non-profit off-takers. (These procurements would meet BEUDO requirements.)
  - "No new fossil fuel supplied buildings" is good idea, but legally problematic. This needs more feasibility research and strategy detail.Also need to study the simultaneous availability of adequate and affordable renewable energy.
  - Need to be realistic about the availability of adequate and affordable renewable energy to meet the demand of widespread electrification of building stock, especially for equity reasons. The timing of supply with demand needs to be aligned.

Slide 31 - 3.2 Rooftop Solar Requirement (Updated)

- Margery Davies
  - There is a good deal of information on the web about integrating green roofs with solar panels -- biosolar roofs. Googling "green roofs and solar panels" leads to lots of references. A survey of the research findings indicates there is widespread agreement that green roofs enable solar panels to operate much more efficiently, by helping to keep them cool, and by cutting down on dust. See, for example:
  - https://icap.sustainability.illinois.edu/files/projectupdate/4207/Solar%20with%20Green%20Roof%20design.pdf
  - and:
  - https://livingroofs.org/green-roofs-solar-power/
  - On balance, I think that combining solar panels with green roofs is not only a feasible idea, it is a good idea. The city would get many additional benefits from green roofs (they absorb rainwater; help cool the air; help reduce air pollution, among others), AND they would enable solar panels to work more efficiently.

Slide 38 – CCA 3.0

- Margery Davies
  - “If the statute stipulates that aggregation programs should be "opt out," then why is the current Cambridge Community Electricity Program (CEP) "opt in"?”

APPENDIX E. SCIENCE, POLICY, TECHNOLOGY, EQUITY FRAMEWORK

2021 NZAP Update
Science, Policy, Tech, Equity Framework

As part of the 2021 NZAP Update the Net Zero Task Force continuously reflected upon three frameworks when considering adjustments to the list of Actions. One of these frameworks was the Science, Policy, Technology and Equity framework. The details of each component of this framework are described here.

Science

This aspect is intended to reflect upon the latest scientific assessments of climate change which tell us emissions need to be reduced 45% below 2010 levels by 2030 and 100% by 2050 to stay below a 1.5-degree increase.

Policy

This aspect is used to inform changes to the NZAP based on what Federal, State and Local Policies have changed in the last 5-years that support our effort to reach the goals (e.g. building energy codes).

Technology

The technology aspect is a reflection upon what enabling technologies have emerged since the 2015 NZAP efforts that may affect and should be considered for emissions reductions strategies.

Equity

A new component of the NZAP, this criteria is used to recognize the social equity implications of policy choices and use an equity assessment framework to help guide the NZAP update process

Science

- Since the adoption of the Net Zero Action Plan in June 2015, the International Panel on Climate Change (IPCC), the body responsible for assessing the science related to climate change, has issued special reports on the impacts of global warming.

- The gap report referenced for this update indicates that to keep to within 1.5 deg C above pre-industrial levels, **emissions need to be reduced 50% below 2010 levels by 2030** and 100% by 2050 maintain the ability to reach this target[1].

- With every passing year, there is more urgency in the scientific imperative, the years since 2015 have been the hottest on record

Source: Christensen, J. and Olhoff, A. (2019). Lessons from a decade of emissions gap assessments. United Nations Environment Programme, Nairobi

Policy

Significant trends or events at the **Federal Government Level** which could influence the NZAP:

- A slowdown in federal policy under the Trump administration for energy efficiency, especially for plug loads, created a gap in behavioral energy use reductions
- Federal pollution regulations and tax credits will continue to play a role in clean energy procurement for the City
- National building codes such as the 2021 IECC set the baseline for state code updates
- Whether policy objectives under the Biden administration are realized could have a large impact on GHG emissions, though they may have less of a direct impact on local building sector emissions

At the State Level:

- The current Three-Year Energy Efficiency Plan for gas and electric utilities expires in 2021 and the updated plan shifted to focus more on GHG emissions. Although the Plan is implemented at the state level, the City can advocate for alignment with local objectives and advance programs for hard-to-reach sectors like multifamily buildings.

- Recent State Legislation:
  - An Act Setting Next Generation Climate Policy (S.2477) sets statewide net-zero emissions limit for the year 2050: It also sets sub-limits for specific sectors
  - An Act Relative to Energy Savings Efficiency (S.2478) that enacts appliance efficiency standards

Policy (Continued)

At the Local Level:

- Since 2015, Cambridge has committed to achieving carbon neutrality by 2050. The faster Cambridge can reduce emissions within its borders, the more the **City can lead** by example in the global effort to combat climate change
- Cambridge voted on the **proposed changes to the IECC** in December 2019 to advance energy efficient design in new construction projects.
- The City will **continue to advocate for a net zero stretch code** at the state level to ensure that state activities align with local interests.
- A fossil fuel ban was considered, however, Brookline's effort to **ban on fossil fuel was struck down** by the State Attorney General. Still other pathways are open for consideration.

Technology

There are many enabling technologies that have emerged since the 2015 NZAP efforts, these include the follow Clean Energy and Energy Efficiency Technologies

- Cold-climate Heat Pumps
- Electric Vehicles (connected load to buildings)
- Battery Energy Storage
- Microgrids
- Lighting and Controls
- Efficiency Gains/Cost Reduction of Renewable Technology

A more comprehensive list is provided in the table below along with their estimated emissions savings and impact potential within Cambridge

Technology Assessment

Tech Category	NZAP Enabling Technologies	Energy Efficiency in Existing Buildings		Net Zero New Construction		Energy Supply		Relative Impact on Overall Future Cambridge Emissions
		Economic	Technical	Economic	Technical	Economic	Technical	
Thermal Tech	**Air / Water Source Heat Pumps**	🟨	⬆	⬆	⬆	n/a	n/a	+++
	Ground Source Heat Pumps	🟨	⬆	🟨	⬆	n/a	n/a	++
DER	**Rooftop PV**	⬆	⬆	⬆	⬆	n/a	n/a	+++
	Solar Thermal	🟨	🟨	🟨	🟨	n/a	n/a	+
	Fuel Cells	🟨	⬆	🟨	⬆	n/a	n/a	+
Energy Efficiency	Lighting Systems	⬆	⬆	⬆	⬆	n/a	n/a	++
	Demand Flexibility	🟨	⬆	⬆	⬆	n/a	n/a	+++
Materials	PCM / Thermal Storage	🔴	🟨	🟨	⬆	n/a	n/a	+
	Cement Alternatives	🔴	🔴	🟨	⬆	n/a	n/a	++
	Glass	🔴	🔴	🟨	⬆	n/a	n/a	++
Thermal Energy Supply	Electrolysis / Hydrogen Blending	n/a	n/a	n/a	n/a	🟨	🟨	++
	Geothermal Districts	n/a	n/a	n/a	n/a	🟨	🟨	++
Grid-scale Renewables	**Wind**	n/a	n/a	n/a	n/a	⬆	⬆	+++
	Microgrids	n/a	n/a	n/a	n/a	🟨	🟨	++
	Off-site RE Procurement	n/a	n/a	n/a	n/a	⬆	⬆	+++

Estimated Level of Feasibility:

🔴 Low 🟨 Moderate ⬆ Strong

Scale of Estimated Potential Impact on Overall Future Emissions:

\+ Minor ++ Moderate +++ Significant

Equity

Cambridge recognizes the social equity implications of such consequential policy choices such as those contained with the NZAP and used Applied Economics Clinic's equity assessment framework helps guide 2021 Update process. The Net Zero Actions entail potential equity benefits and pitfalls and, in some cases, are equity neutral.

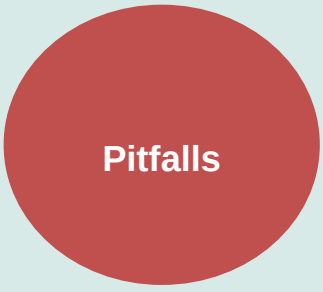
- Potential **equity benefits** include:
  - Improved indoor comfort and air quality,
  - Lower energy bills,
  - Increased access to financing and funding,
  - Enhanced energy reliability, and
  - Increased resident engagement, awareness, and participation

- Potential **equity pitfalls** include:
  - Housing cost and rental cost increases,
  - Energy cost increases,
  - Inequitable program participation, and
  - Inequitable distribution of benefits and burdens.

- Potential **equity pitfalls can be avoided** by incorporating specific policy language that targets equity and builds in flexibility so that policies can be adjusted if inequitable impacts arise.

The checklist provides a method to ensure a robust treatment of climate and social equity.

Social equity cuts across many dimensions, each of which requires consideration.



Each dimension has common equity pitfalls that should be acknowledged and mitigated should they arise.

APPENDIX F. Methodology for GHG Emissions Inventory for Buildings

METHODOLOGY FOR BUILDING STOCK GHG EMISSIONS INVENTORY

Greenhouse gas emissions inventories are developed to help government leaders and corporate managers understand how greenhouse gas (GHG) emissions are associated with various activities in their community or business. For cities, GHG emissions are generally compiled at both the community scale and at the government operations scale. In 2017, The City completed a GHG emissions inventory for the Cambridge community as a whole. The community-wide inventory follows the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) which was developed by the World Resources Institute, C40 Cities, and ICLEI Local Governments for Sustainability and is required by The Global Covenant of Mayors for Climate and Energy (Global Covenant)[1], of which Cambridge is a member. The methodology specified by the GPC is what was used for the Building Stock Inventory completed as part of the 2021 NZAP and is further described below.

1.1 Building Sector Stationary Energy – Electricity

Electricity generation in Massachusetts is made up of a mix of natural gas, nuclear, coal, hydroelectric, and other renewable generators, and accounts for over 20% of Massachusetts's total GHG emissions. Much of the electricity used in the Commonwealth is imported from power plants located in other states and in Canada. At the city level, electricity consumption is primarily considered a Scope 2 emissions source.

Data Summary

Grid-supplied electricity is provided throughout the city and powers the residential, commercial, and industrial sectors, in addition to city infrastructure and transport systems. The City of Cambridge has a single electricity provider, Eversource, to transmit and distribute electricity. As such, Eversource was the primary source for gathering electricity consumption data in the city. Real consumption data was used to determine the electricity consumption (kWh/year) from each building sector.

When coordinating with Eversource to acquire the sector level consumption data for future inventories, Special Ledger Accounts are also reviewed. These Special Ledge Accounts are maintained separately from the general population account data and are associated with customers who require that their account information be kept private. These types of accounts exist for both electricity and natural gas customers. DNV gathered the electricity and gas consumption data from Eversource for both these customer types for the years 2012-2019.

GPC Quantification Method Used

In accordance with Section 6.5 of the GPC, the location-based method was used for the inventory. Reported emissions from all grid-supplied electricity consumed within the city's boundaries were reported as Scope 2 emissions. BASIC/BASIC+ reporting avoids double counting by excluding Scope 1 emissions from electricity generation supplied to the grid.

The grid-based average emission factor is necessary due to the imprecise available supply balance of electricity generated and consumed within the city boundaries. The emissions factor used for grid supplied electricity is provided in

[1] The Global Covenant of Mayor's for Climate and Energy is the new designation for the Compact of Mayors. The Compact of Mayors was launched by UN Secretary, C40 Cities Climate Leadership Group (C40), ICLEI – Local Governments for Sustainability (ICLEI) and the United Cities and Local Governments (UCLG) –with support from UN-Habitat, the UN's lead agency on urban issues.

Table 1 and is based on data from ISO New England[2]. In addition, methane (CH4) emissions as well as nitrous oxide (N2O) emissions from grid supplied energy also need to be taken into account to determine the total CO2 equivalent (CO2e) emissions factor. The CH4 and N2O emissions rates were gathered from the U.S. Environmental Protection Agency's eGRID data.

[2]ISO New England. "2012 ISO New England Electric Generator Air Emissions Report" www.iso-ne.com/static-assets/documents/genrtion_resrcs/reports/emission/2012_emissions_report_final_v2.pdf

Table 1: ISO New England 2012 Electricity System Emissions Rates Used for Inventory

Year	CO_2 Emission Factor (lbs CO2 / MWh)	CO_2 Emission Factor (MT CO2 / kWh)
2012	719	0.000326
2013	730	0.000331
2014	726	0.000329
2015	747	0.000339
2016	710	0.000322
2017	682	0.000309
2018	658	0.000298
2019	658	0.000298

1.2 Building Sector Stationary Energy – Natural Gas

The primary uses for natural gas in the City of Cambridge are for space heating, water heating equipment, and co-generation stations. The emissions from the co-generation units are attributed to fuel burned for heat, steam and electricity generation. The emissions from these sources are defined as Scope 1 emissions.

As previously noted, Eversource maintains a list of Ledger Accounts for both electricity and natural gas customers. Special Ledger Account were included. In addition, data was used from the U.S. EPA's Large Facilities Database to determine emissions associated with co-generation facilities within the city of Cambridge. The approaches to estimating the emissions from natural gas consumption in the buildings sectors and by the co-generation plants are summarized separately below because of the different approaches used for each.

Data Summary

Building Sector

Grid-supplied natural gas is provided throughout the city and is primarily used by the residential, commercial, and industrial sectors for heat and hot water production. The City of Cambridge also has a single provider for natural gas, Eversource. As such, Eversource was the primary source of information for natural gas consumption in the city. Metered data was used as the source of the annual therm consumption for each building sector.

In addition to the Building Sector natural gas usage, the GPC also requires the losses from distribution systems be accounted for. Based on an assessment of several studies that have been done on the subject of gas leakage from the distribution system network in and around the Boston, we determined that an average leakage rate of 0.6% was appropriate for the inventory (see PNAS Article). According to the Harvard study Methane emission and Natural Gas delivery data reported to both the US Environmental Protection Agency and Massachusetts GHG Reporting Programs show loss rates of 0.4–1.6% among individual distribution companies in Massachusetts in 2012 and 2013, with an average of 0.6%, weighted by delivered natural gas volumes (Kathryn McKain, 2015).

Co-generation Systems

There are four large electricity and steam generation facilities located in Cambridge that were assessed as part of this inventory: The Kendall Cogeneration Station, the MIT Central Utilities Plant, the Harvard University Blackstone Plant, and the Biogen IDEC plant.

Consumption and emissions data for these facilities were gathered from publicly available reports provided on the U.S. EPA's Greenhouse Gas Reporting Program website (https://ghgdata.epa.gov/ghgp/main.do#). These facilities are required to report biogenic CO2 emissions and CO2 emissions excluding biogenic CO2 separately.

The Kendall Cogeneration Station is a 256MW steam and electricity energy plant. The primary gas turbine produces electricity and high pressure steam. This steam is recycled to power secondary steam turbines to generate additional power. For emissions inventory, all emissions are allocated to Cambridge. ISO NE emissions factors includes units that are least 25 MW in capacity. To avoid double counting, the Kendall Co-generation Station should only be included in the Scope 1 territorial emissions.

Harvard University manages the Blackstone Steam Plant. This plant uses four dual-fuel boilers operating primarily on natural gas. They have a service area covering a substantial portion of Harvard's campuses extending from Harvard Yard, the Law School and Divinity School in the North campus, along the River Houses, across the river to the Harvard Kennedy School, and Athletics and One Western Avenue in Allston. The boilers generate up to 5.7MW of electricity through it's back-pressure turbine system. While steam is used on properties in Boston, the CHP plant is located within Cambridge's boundaries, and therefore has been included in whole to this inventory. A CHP unit was added to the Blackstone plant in 2013 with an 8 MW turbine generator and is included in the inventory data for years 2015-2019.

MIT's Central Utilities Plant is a 21-megawatt natural gas turbine used to produce both electric and thermal energy for the campus. The heat recovery steam generator captures waste heat from turbine exhaust, and the captured steam is used for heating and cooling (via chillers driven by steam turbines). Emissions from this plant that were reported to the U.S. EPA were included for the years 2012-2019.

The BioGen IDEC facility is a 5.3MW natural gas turbine with a heat recovery steam generator (HRSG). This system operates in parallel with the electric utility. Emissions from this plant that were reported to the U.S. EPA were also included for the years 2012-2019.

GPC Quantification Method Used

Buildings Sector

In accordance with Section 6.3 of the GPC, real consumption data for each fuel type, disaggregated by sector was used for the inventory. Reported emissions from the usage of natural gas within the city's boundaries were reported as Scope 1 emissions. Because Eversource-specific emission factors for natural gas emissions were not available, a universal emission factor provided by the Climate Registry[3] was used to calculate natural gas emissions. The emissions factor used for natural gas consumption is provided in Table 2.

In addition, methane (CH4) emissions associated with distribution systems leakage also needs to be taken into account in the inventory. The total CO2 equivalent (CO2e) emissions factor for fugitive emissions from natural gas leakage was determined based on:

- Volume of natural gas per heat energy (m3 gas / therm gas)
- A density value of natural gas of 0.7 kg/m3 based on values provided in the GHG Protocol stationary combustion tool.
- The IPCC Tier 1 default for the mass fraction of methane in delivered natural gas (93.4%).
- A carbon dioxide content of 1.0% in the delivered natural gas.

The overall emissions factor was then calculated to be 0.04628 MT CO2e/leaked therm.

[3] 2015 Climate Registry Default Emissions Factors, released April 2015

Table 2: Natural Gas Consumption Emissions Rate

Type of Emission	CO_2 Emission Factor (kg CO2 / MMBtu)	CO_2 Emission Factor (MT CO2 / Therm)
Natural Gas Consumption	53.06	0.0053

*Note CH4 or N2O are not included because these emissions are considered to be de minimis

Co-generation Systems

In accordance with Section 6.3 of the GPC, the community-wide inventory for the City of Cambridge used the Real-consumption data, disaggregated by sub-sector approach. The emissions associated with these facilities are taken directly from the EPA reports which are submitted by large facilities and use standard emissions calculation methodologies. Facilities generally have some flexibility in choosing which calculation method to use and their methods may change from year to year as long as the still meet the requirements of the U.S. EPA's Greenhouse Gas Reporting Program.

1.3 Building Sector Stationary Energy – Fuel Oil

The baseline for energy-use in Cambridge for the residential, commercial and industrial sectors in Massachusetts communities includes fuel oil consumption as well. While electricity and natural gas heating are limited to specific municipal suppliers, fuel oil is supplied by many different private companies. Because customer data cannot be collected from each supplier, consumption must be estimated using community-specific assumptions. Any limited fuel oil usage by the Kendall Station, Blackstone plant, and MIT CUP is accounted for in the U.S. EPA Greenhouse Gas Reporting Systems reports.

Data Summary

For the Cambridge community-wide inventory, residential oil usage data was based on the number of housing units in Cambridge by type, and a percentage of units determined to be heated with fuel oil from the "American Community Survey (ACS) 2010-2014 5-Year Community Estimate." The property types identified were:

- Single-Family, Detached
- Single-Family, Attached
- Multi-Family, 2-4 Units (Sum of 2-Family and 3-4 Units categories)
- Multi-Family, 5+ Units (Sum of 5-19 Units, 20-49 Units, and 50+ Units categories)
- Other

Residential fuel oil combustion emissions were totaled using state average use and expenditure by fuel type and applied to Cambridge housing data. Massachusetts has a lower concentration of single family homes and a higher concentration of two- to four-unit apartments. To account for this when comparing an average Massachusetts home with an average New England home (averaged across all housing units), a weighted New England Average Consumption based on the percentage breakdown of housing unit types in Massachusetts was used.

For the Commercial sector, fuel oil use estimates were based on the total number of employees, establishments by Primary Building Activity (PBA), and the average expected energy use per employee for each PBA. The Executive Office of Labor and Workforce Development (EOWLD) ES-292 Employment and Wages Survey lists the number of employees and

establishments by industry, sorted by North American Industry Classification System (NAICS) codes.[4] The EIA 2012 Commercial building Energy Survey (CBECS) analyzes energy use and consumption data based on Primary Building Activity (PBA).

The crosswalk provided in **Table 3** (generated by EIA) roughly correlates the PBA codes used in CBECS with standard three-digit NAICS codes between 400 and 1000.

Table 3: NAICS code crosswalk table for identifying Primary Building Activity

PBA	NAICS Code (3-digit)
Education	611
Food Sales	445
Food Service	722
Inpatient Health Care	622
Outpatient Health Care	621
Lodging	623, 721
Retail (non-mall)	441, 442, 443, 444, 451, 452, 453, 532
Retail (mall)	446, 448
Office	454, 486, 511, 516, 517, 518, 519, 521, 522, 523, 524, 525, 561, 624, 921, 923, 924, 925, 926, 928
Public Assembly	481, 482, 485, 487, 512, 515, 711, 712, 713
Public Order/ Safety	922
Religious Worship	813
Service	447, 483, 484, 488, 491, 492, 811, 812
Warehouse/ Storage	423, 424, 493
Other	562, 927

Certain data required alternate collection methods due to a lack of direct employee data. PBA's with incomplete data used one of two options for estimating the missing data for the purposes of this baseline:

- Option 1: Compare average fuel oil use to average natural gas use in the same building types, using Office buildings as a baseline. For example, if a PBA that uses natural gas uses 50% more natural gas than an Office building, assume that if the same PBA used fuel oil, it would use 50% more fuel oil than an Office building. This is the preferred method, as it yields a more conservative estimate.
- Option 2: Find average fuel oil consumption for an average New England building (across all PBAs) and divide

For the industrial sector, data was collected similarly to Commercial data. The total number of employees and establishments by PBA, and the average expected energy use per employee for each PBA. EOWLD ES-202 Survey lists the number of employees and establishments by industry, sorted by NAICS codes.[5] This sector encompasses NAICS codes between 311 and 339 as shown in

[4] Executive Office of Labor and Workforce Development. "EOWLD ES-292 Employment and Wages Survey" http://lmi2.detma.org/lmi/lmi_es_a.asp

[5] Executive Office of Labor and Workforce Development. "EOWLD ES-292 Employment and Wages Survey" http://lmi2.detma.org/lmi/lmi_es_a.asp

Table 4. Industrial energy uses between 100 and 200 (such as power generation and utility operations) were not incorporated in this methodology. The EIA 2012 Manufacturing Energy Consumption Survey (MECS) analyzes energy use and consumption data based on Primary Building Activity (PBA).

Table 4: Industrial NAICS Codes

NAICS_3	Industry	NAICS_3	Industry
311	Food	326	Plastics and Rubber Products
312	Beverage and Tobacco Products	327	Nonmetallic Mineral Products
313	Textile Mills	331	Primary Metals
314	Textile Product Mills	332	Fabricated Metal Products
315	Apparel	333	Machinery
316	Leather and Allied Products	334	Computer and Electronic Products
321	Wood Products	335	Electrical Equip., Appliances, and Components
322	Paper	336	Transportation Equipment
323	Printing and Related Support	337	Furniture and Related Products
324	Petroleum and Coal Products	339	Miscellaneous
325	Chemicals		

As previously mentioned, fuel oil consumption from the Kendall Cogeneration Station, Blackstone plant, and MIT CUP are reported directly from the EPA Greenhouse Gas Reporting Program submittals and therefore were not estimated here.

GPC Quantification Method Used

In accordance with Section 6.3 of the GPC, the emissions from these Stationary Energy sources are calculated by multiplying activity data by the corresponding emission factors for each fuel. Estimated energy consumption by fuel type, applicable consumption rates, and the total quantity of energy consumption overall are used to obtain a percentage that can be used to approximate how much of each fuel type is used by each sector in the community.

As detailed above, a collection of representative consumption surveys, modelled energy consumption, and regional fuel consumption data was used to properly characterize the City of Cambridge emissions. Being that there is likely a higher number of employees per square foot in Cambridge than industry averages, oil consumption emissions are likely overestimated in this inventory.

APPENDIX G. 2021 NZAP Model Methodology

METHODOLOGY FOR 2021 NZAP MODELLING

The NZAP tool was developed to evaluate the impacts of NZAP actions taken to date, track progress towards the goals of each action, and forecast emissions reductions from these activities over time. The tool was developed based on available data and input from city staff and stakeholders. The NZAP tool is an Excel-based modelling tool that DNV created for the City that can serve as a centralized hub of NZAP Action-related information. This tool was based off similar tools DNV has developed including a Climate Scenario Analysis Tool that has been used with a number of leading cities to evaluate, prioritize, and track progress on a wide range of actions designed to dramatically reduce emissions in the built environment.

The tool was designed in a way that incorporates key pieces of data from existing analyses and data sources – including but not limited to the 2018 Climate Action Plan model, 2017 Low Carbon Energy Supply Strategy (LCESS) model, the Community-wide GHG Inventory (2017) and building stock inventory, growth, and renovation analysis. Using these sources ensures that consistency is maintained across study efforts when managing the 2021 NZAP actions.

Given the City's desire for ongoing tracking of NZAP progress, the replicability of procedures was critical in creating a user-friendly tool that city staff can use to make adjustments and track progress. Producing a highly organized and well documented Excel-based tool also allows the City to maintain a consistent program evaluation protocols that will enable well organized and detailed tracking across years. Working with city staff, DNV conducted a full review of indicators or metrics used to track progress in the NZAP Annual Report, BEUDO, and GHG Inventory and worked with city staff to determine the best way to incorporate indicators the 2021 NZAP Assessment Tool. Through this process a series of additional indicators were identified and documented (see Appendix C) to ensure consistent and relevant tracking of progress over time. This document provides additional information on methodologies and data sources incorporated into the tool.

Note that, like any model, the NZAP tool is merely a representation of the future and therefore should not be relied on as a precise prediction. The Net Zero Action Plan is meant to be a high-level framework for action to reduce GHG emissions from buildings and lacks the specificity needed to model precise results, such as exact kWh and therms reduced by an action in a certain building sector. Therefore, rather than expecting the NZAP model to determine whether Cambridge will hit specific GHG reduction targets, it should be used to observe the general magnitude of impact of each action relative to the other actions and the interaction between them.

1.1 Notes on General Use of the Tool

The 2021 NZAP Assessment Tool is organized into a series of tabs. Across the bottom of the workbook the user will note the different colored tabs.

- The yellow tab (CO2 Impacts Map) is a guide for the user on which actions have quantifiable emissions reductions and which actions are considered "Enabling Actions"
- The dark green tabs are those tabs that the user inputs tracking data and sees the outputs
- The light blue tabs are where the calculations are performed for each action
- The dark blue tabs are where reference data is accessed for the calculations
- The gray QC Tables tab is included so the user may conduct further quality control checks on the outputs and compare results across scenarios.

The tool is set up to input tracking data and output a set of consistent metrics across each action with quantifiable impacts. The inputs are unique to each action but are metrics that can be used to calculate energy and emissions impacts. To track progress, the user needs to input data for each action on an annual basis. Once a new set of inputs is entered the user will

receive back a set of impact metrics to understand the emissions impacts overall and by decarbonization strategy. These are:

- CO2e Reductions from Energy Efficiency improvements
- CO2e Reductions from On-site Renewable Electricity
- CO2e Reductions from Off-site Renewable Electricity purchases
- Total cumulative avoided emissions from that action up to the latest input year

This setup allows the user to see the source of emissions reductions for each action. Some actions may have multiple sources. For example, BEUDO Performance Requirements will show emissions reductions from both energy efficiency and Off-site Renewable Energy. As it is, no amount of emissions reductions will appear in the On-site Renewable Electricity column from any action due to the current practice being that RECs are primarily held or retired by those outside of Cambridge.

In addition to the inputs for each action, the tool also may be updated with the most recent building sector inventory data. As the building sector inventory is updated that inventory data may be entered in the Stationary Energy Emissions table at the top of the sheet. This will affect the forecasted emissions projections through 2050 shown in the charts on the NZAP Dash tab.

While the Inputs and Outputs tab is designed to help understand the impacts of actions to-date, the NZAP Dashboards are designed to be more forward looking. NZAP Dash by Action and NAZP Dash by Source provide a series of charts that show the projected emissions and overall avoided emissions through 2050. The user may toggle between individual actions on the NZAP Dash by Action tab or view emissions avoided by strategy (energy efficiency, on-site renewable electricity and off-site renewable electricity) by selecting “On” from the dropdown menu in the NZAP Dash by Source tab. Note that when viewing emissions avoided by action, the bar chart below the wedge chart will populate as will the waterfall charts. When viewing emissions avoided by source, a donut chart on the left is included to show the percent of savings by source.

The charts use the data from the table in tab ‘Dash Engine’. The Dash Engine pulls from the calculation tabs for each action. There is no need for the user to edit any of the cells in the Dash Engine tab.

Scenarios

The NZAP Dash by Action tab includes a series of tables which allow the user to toggle through various scenarios. Using Table 1, the user may choose between different electric grid scenarios. These scenarios reflect different rates at which the Massachusetts Renewable Portfolio Standard (RPS) and Clean Energy Standard (CES) may reach 100% emissions-free electricity. These are as follows:

- Grid 1 – Electric grid emissions absent any state-level intervention (no RPS or CES). This is the business-as usual case.
- Grid 2 – Current RPS/CES; the electric grid reaches 80% emissions-free by 2050.
- Grid 3 – Assumes under the RPS/CES, the electric grid reaches 50% emissions-free by 2030, and 100% emissions free by 2050
- Grid 4 – Assumes under the RPS/CES, the electric grid reaches 75% emissions-free by 2030, and 100% emissions free by 2050

- Grid 5 – Assumes under the RPS/CES, the electric grid reaches 100% emissions-free by 2030

Tables 3a, 3b and 3c allow the user to toggle between various action-related scenarios. Table 3a includes different scenarios for Actions 1.3 Transaction Points, 3.1 Low Carbon Thermal Energy Supply and 3.2 Community Access to Renewable Electricity. Table 3b is related to Action 3.3, Off-site Renewable Electricity Access, and participation levels in the community choice aggregation program – how many customers participate in the program and of those participating, how many purchase 100% renewable electricity. Using Table 3c the user may alter the rate or pace at which BEUDO buildings achieve net zero emissions. These scenario options and their use are further described in the dashboard tab beneath the tables.

1.2 Notes on calculation methodologies

This section provides clarification on how inputs are used and assumptions that are built into the model due to data limitations for each of the actions.

Action 1.1 EE Retrofits

Inputs

For the calculations, this action requires data from completed retrofit projects to populate the model. Inputs include number of projects completed, estimated kWh and Therms savings from those projects. If no tracking data is input, default values will be used for the projections.

Data limitations and Assumptions

As of 2020, no kWh or Therm savings were reported from this action; therefore, there are no measured input for this action. All of the projected savings are based on a series of assumptions which the consulting team found reasonable to include as part of the model.

Where there is no real data, an assumed kWh Saved, and Therm Saved per Project is used. These assumptions are based on a review of recent studies including the Cambridge Interventions Points study (2020).

An assumed number of projects completed per year is also used. We currently assume 50 projects per year can be completed based on recent engagement trends with residents and businesses through the Cambridge Energy Alliance (CEA) programs. These values can be found in the Reference Data tabs and can be adjusted if better information becomes available.

Calculations

To calculate emissions reductions over time, electric and gas emissions factors for use are used as well as an emissions factor for gas distribution losses[1] (MT/project/year). This is based on Electricity Emissions Factors and Natural Gas Emissions Factors found in the reference data tabs and the average kWh and Therms saved per project. The source of the electric and gas factors was the Climate Action Plan Buildings Model created several years back for the city.

Since all emissions from this action are related to energy efficiency, the emissions reductions are determined by applying the Fuels Emissions Factor Per Project Factor to the Number of Projects Completed.

[1] Fugitive emissions from gas distribution systems have a different emissions factor than gas combusted on-site; therefore, the calculation for total gas emissions must consider these two aspects separately. Emissions resulting from electricity use and through electric distribution losses use the same emissions factors and may be combined to determine total emissions from electric use.

Note that because savings from the retrofit action will transition to Action 1.3, Upgrades at Transaction Points, in the future, a 'Transition Factor' has been built into the model (Column P). Currently the model estimates that all savings will be attributed to Action 1.1 through 2024, 50% will be attributed in 2025 and 2026, and after 2026, all savings will be transitioned to Action 1.3.

Action 1.2 BEUDO Requirements

Inputs

The tracking inputs associated with the BEUDO Requirements currently do not factor into the emissions projections other than to establish a baseline for the performance requirements. This is because the performance requirements are still in the process of being formally adopted. Once they take effect, emissions reductions will be attributed to this action. In the model, it is assumed these requirements will first yield results in 2025.

As it is, emissions reductions are based on a kWh and Therms from the baseline year 2019.

Data limitations and Assumptions

Emissions reductions from BEUDO are associated with the performance goals being met that are currently laid out for the policy. Those are:

- By 2025 emissions will be reduced by 20%
- By 2030 emissions will be reduced by 40%
- By 2035 emissions will be reduced by 60%
- By 2040 emissions will be reduced by 80%
- By 2045 emissions will be reduced by 90%
- By 2050 emissions will be reduced by 100%

The emissions reductions are estimated using energy data from the year 2019. For instance, by 2030 there will be a 40% reduction in emissions from the 2019 reported energy use.

For this Action emissions reductions are split between energy efficiency, on-site and off-site renewable energy procurement. The model uses an assumption that of the emissions saved in year [X], a certain percent of that will be associated with energy efficiency improvements and the remainder will be associated with renewables. The energy efficiency savings potential is shown in the model as the Energy Efficiency Potential (Column AB). The model currently assumes a 1% energy efficiency potential each year for the BEUDO Performance Requirements which may be a conservative estimate considering MassSave Energy Efficiency Programs generally use a 2-5% potential for program planning[2]. A Realization Factor is also taken into consideration in the calculations – that is, of the potential savings from energy efficiency available, how much will be realized in that year. This factor declines over the years.

Calculations

The emissions reductions calculations are performed 2 ways – both arrive at the same results. The first way emissions reductions are calculated is strictly based on the Policy Targets (Column AO). This is the difference between baseline emissions and forecast emissions with targets in place (Column Z). The second way uses EE Potential to determine how

[2] See Massachusetts Joint Statewide Electric and Gas Three-Year Energy Efficiency Plan, 2022-2024 (April 30, 2021)

much emissions reductions will come from energy efficiency, on-site renewables, and off-site renewables. The total emissions reductions calculated from potential (shown in Column AU) is:

EE potential + On-site Solar Growth + what is needed to purchase as off-site RE to reach targets

Each method uses the baseline kWh consumption for electricity use and Therms consumption for gas use in BEUDO buildings as a basis for quantifying reductions. The user will notice the energy use is the same for each year (Columns T and U). This is because growth is assumed to be addressed by Action 2.1 Net Zero New Construction.

Emissions from electricity use and gas use are determined by applying an emissions factor to each fuel. These emissions factors are pulled from the reference data tabs. The emissions reductions are calculated as a percentage of the emissions reduced from the baseline energy use at year [X] according to the BEUDO Targets. The targets list above may be adjusted by the user using Table 3c in the Dash by Action tab to determine the effects of accelerating the pace of BEUDO emissions reductions in relation to the overall ZNE goals such as the UNEP 2030 goal.

As mentioned above, the savings are split between energy efficiency and renewable access. A conservative 1% of savings is estimated to come from energy efficiency, the remainder will come from renewables, including fuel-switching from fossil fuel to electric energy systems.

Action 1.3 Upgrades at Transaction Points

Inputs

For the calculations, this action uses data from completed retrofit projects to populate the model. Inputs include number of projects completed, estimated kWh and Therms savings from those projects.

Data limitations and Assumptions

This action has not yet been formally adopted so no tracking data is currently available. All of the projected savings are based on a series of assumptions which the consulting team found reasonable to include as part of the model which can be found in the Ref Data and Assumptions tab.

Since there was no tracking data available, an assumed Therm Saved per Project was used as well as an assumed number of projects completed per year is also used. We currently assume 742 projects per year completed based information provided as part of the Cambridge Intervention Points Report (2021). These values can be found in the Reference Data tabs and can be adjusted if better information becomes available. kWh savings are not considered in this action because the emissions reductions associated with electricity use in these sectors (residential and small commercial) are covered by Action 3.2 and 3.3.

Calculations

To calculate emissions reductions over time, a gas emissions factor is used (MT/project/year). This emissions factor is calculated based on natural gas use and the fugitive emissions associated with that use. The emissions factors may be found in the reference data tabs. The source of the gas factors was the Climate Action Plan Buildings Model created several years back for the city and the City's GHG Inventory (2017).

Since all emissions from this action are related to energy efficiency, the emissions reductions are determined by applying the Fuels Emissions Per Project Factor to the Number of Projects Completed.

Note that because savings from the retrofit action will transition to this action, a 'Transition Factor' has been built into the model (Column Q). Currently the model estimates that all savings will be attributed to Action 1.1 through 2024, 50% will be attributed to this action in 2025 and 2026, and after 2026, all savings will be transitioned to Action 1.3.

Action 2.1 Net Zero New Construction

Inputs

For the calculations, this action requires data on the number of projects permitted, square footage of project and number of units associated with multi-family housing projects. If these inputs are not provided the model defaults to assumed values.

Data limitations and Assumptions

New buildings in Cambridge are not yet subject to NZE requirements, therefore no tracking data is currently incorporated in the model. All of the projected savings are based on a series of assumptions which the consulting team found reasonable to include as part of the model.

The key assumptions used in the calculations for these actions are:

- Projected growth – a growth factor as determined by the regional planning agency for the region. This growth factor is associated with Job's growth for the city.
- An average kWh and Therm per square foot of new building based on data from the U.S. Energy Information Administration
- Current square footage of buildings in Cambridge

Calculations

To calculate emissions reductions, first the growth factor is applied the to the total square footage of buildings in Cambridge. From that the square feet added per year is determined.

Using the kWh and Therm intensity factors, the kWh and Therm consumption associated with the new building area is determined.

To determine the emissions from this new building area over time, a ZNE transition factor is applied. This is a percentage of new building stock that will be ZNE at a given point in the future. It's expected that all new buildings will be net zero by 2030. As the user will note, at year 2030 100% of the new construction will be net zero meaning there will be no new emissions added from new construction activities after that time.

Similar to the Action 1.1 and Action 1.3, there will be a transition from the savings achieved from the Green Building Requirements to this action. That is because once the net zero requirements are fully adopted, all new building whether they are green buildings or not, will be required to be net zero. This action, therefore, also has a transition factor built into the calculations.

The emissions avoided from this action are the total emissions expected from electricity and gas use from newly constructed buildings minus that portion which is expected to be net zero. For example, where 0% of buildings are expected to be net zero there are no emissions avoided. If 50% of buildings are expected to be net zero in a given year, then 50% of the emissions from those buildings will be avoided. A portion of the remainder of the emissions will be saved through Action 1.3, Green Building Requirements, until that time when all buildings are required to be net zero.

For this action the savings are again expected to be split between energy efficiency and renewable access. For new construction, it is assumed that a higher level of savings will come from energy efficiency improvement beyond what is considered baseline. For modelling purposes this is estimated to be 50% of the savings. This percentage is applied to the total emissions avoided to determine emissions avoided from energy efficiency and emissions avoided from renewable energy.

Action 2.3 Green Building Requirements

Inputs

For the calculations, this action requires data on the number of projects permitted, square footage of project and number of units associated with multi-family housing projects. If these inputs are not provided the model defaults to assumed values.

Data limitations and Assumptions

Limited tracking data was available for this action, but the emissions savings from green building projects between 2015 and 2019 are taken into consideration in the model. Savings are based on a series of assumptions which the consulting team found reasonable to include as part of the model.

The key assumptions used in the calculations for this action are:

- Energy savings from green buildings – assumed to be 10% based on LEED projects achieving at least 2 points for EA Energy Performance Credit / v4.1 equivalent to MA Base Stretch Code (ASHRAE 2016-90.1)
- Projected growth – a growth factor as determined by the regional planning agency for the region. This growth factor is associated with expected Job's growth for the city.
- An average kWh and Therm intensity per square foot of new building based on data from the U.S. Energy Information Administration
- Current square footage of buildings in Cambridge

Calculations

To calculate emissions reductions over time, first the growth factor is applied the to the total square footage of buildings in Cambridge. From that the square feet added per year is determined.

Using the kWh and Therm intensity factors, the kWh and Therm consumption associated with the new building area is determined.

The emissions avoided are determined by then applying savings from green buildings to the total emissions expected from electricity and gas use. The results are that portion of the electric and gas usage considered to be saved from the green building requirements. The transition factor described in Action 2.1 is then taken into consideration and applied to estimate the emissions avoided from this action in the absence of the net zero requirements. All emissions reduction for this action are considered to be associated with energy efficiency because of the issue with RECs from on-site renewable energy systems likely being attributed elsewhere and off-site renewable not being needed as part of the green building certification process.

Action 2.4 Municipal Building Requirements

Inputs

For the calculations, this action uses data from completed projects to populate the model. Inputs include number of projects completed, estimated kWh and Therms savings from those projects.

Data limitations and Assumptions

Tracking data was available for this action and the emissions savings from those projects are taken into consideration in the model. Projected savings are based on a set of assumptions that are informed by the realized savings from the tracking data. These include:

- An average kWh and Therm savings per project
- An assumed number of projects completed per year

The user will note that some years appear to be outliers, however, these years with large savings recorded are associated with the completion of a large projects (such as a new school). Although these years may skew the averages, they are left in assuming the city will continue to periodically complete large projects as part of the Municipal Facilities Improvement Plan.

Calculations

To calculate emissions reductions over time, a combined (electric and gas) emissions factor is used; that is, an estimated combined metric ton of CO2e per project per year (MT/project/year). This is based on Electricity Emissions Factors and Natural Gas Emissions Factors found in the reference data tabs and the average kWh and Therms saved per project. The source of the electric and gas factors was the Climate Action Plan Buildings Model and the City's GHG Inventory (2017).

Since all emissions from this action are related to energy efficiency, the emissions reductions are determined by applying the Combined Fuels Emissions Per Project Factor to the Number of Projects Completed.

Action 3.1 Low Carbon Energy Supply

Inputs

The calculations for this action are not based on any tracking data currently. They are projections based on a number of assumptions about this Action. As it is, the emissions savings are expected to come from the transition to ZNE in the small commercial sector (non-BEUDO) and from the residential sector where fossil fuel-based heating equipment will be converted to electric equipment. The savings in the residential sector are realized through the efficiency gains as a result of equipment replacements and the use of less emissions intensive electricity for heating.

Data limitations and Assumptions

The Clean Heat Program is seen as the primary program for delivering emissions reductions from this action. Although the Clean Heat Program is being implemented no tracking data was available at the time of the model development. All of the projected savings are based on a series of assumptions which the consulting team found reasonable to include as part of the model.

The key assumptions used in the calculations for this action are:

- Electric and gas use of non-BEUDO, small commercial buildings
- The rate net zero emissions are achieved in the non-BEUDO, small commercial buildings sector
- Average kWh Use per Unit (Residential) – Based on Eversource billing data

- Average Therms Use per Unit (Residential) – Calibrated based on information provided in the Cambridge Resilient Renewable Thermal Analysis (2020).
- Number of projects completed per year – assumed to be 531 projects per year completed based on Cambridge Resilient Renewable Thermal Analysis.

Taken into consideration in the calculations is also the improvement in efficiency when switching to a heat pump. The efficiency used for a new heat pump is a COP of 2.4 which is also per the Cambridge Resilient Renewable Thermal Analysis.

Calculations

The calculations for the non-BEUDO, small commercial sector proceed as follows:

- First the estimated emissions from gas use are calculated based on the square footage of non-BUEDO buildings existing in Cambridge in 2019 (this is based on comparison of BEUDO data to all building in Cambridge – see separate analysis)
- It is then assumed that all emissions will be removed by 2050 at a consistent year-over-year pace (note that the pace may be accelerated using Table 3a on the Dash by Action tab)
- The annual emissions reductions are then summed with the reduction from the residential sector to get total emissions reductions

The calculations for Residential Sector for this action proceed as follows:

- Based on the Average Therms per Unit and the number of projects each year a Therms [to be] Replaced value is determined
- Therms are then converted to kWh for the equivalent electric use (this conversation takes into account the gains in efficiency)
- The would be Therms emissions are calculated along with the emissions associated with the equivalent electric use
- The difference between the two is the emissions reductions realized through fuel switching

Action 3.2 On-site Renewable Electricity – Community Solar Access

[Note: this action is not considered to have any impact on emissions in Cambridge due to the RECs from on-site renewable energy project likely being attributed to other outside of the City. The calculation sheet is available however, if this situation should change.]

Inputs

For the calculations, this action uses data from completed projects to populate the model. Inputs include the number of projects completed, and the total capacity (kW) of those projects.

Data limitations and Assumptions

Tracking data was available for this action and the emissions savings from those projects are taken into consideration in the calculations. Projected renewable electricity production is based on a set of assumptions including:

- An average kWh produced per project (kWh/kW/year) – this is based on information from the National Renewable Energy Laboratory's PV Watts tool)

- An assumed growth factor for new solar installs in the city

Calculations

The calculation to determine the projected electricity production from these systems in the city proceed as follows:

If tracking data is available:

- The model uses the total capacity (kW) installed for that year
- The total electricity produced from those systems is determined by applying the average electricity production (kWh/kW/year) to the total capacity to arrive at a kWh/year produced.

If projections are used the model uses the assumed growth factor to determine what the install capacity would be in year [X] based on the most recent year of tracking data (currently 2019, 501 kW installed). The total electricity produced from those systems is again then determined by applying the average electricity production (kWh/kW/year) to the total capacity to arrive at a kWh/year produced for that year.

Action 3.3 Off-site Renewable Electricity Access

Inputs

The Off-site Renewable Electricity Action is intended to both be enabling and have direct emissions impacts. It will be enabling provided the criteria that large commercial buildings can use the aggregation to meet BEUDO requirements. It will have direct impacts by providing a structure under which residential and small businesses can buy renewable electricity from the market. For the impact calculations, this action uses data from the Community Choice Aggregation program to model the renewable electricity estimated to be purchased by residents and small businesses as a result of this action. Inputs include the number of residential and commercial customers participating in the Green Plus product (100% renewable electricity) offered as part of the community choice aggregation program.

Data limitations and Assumptions

Tracking data was available for this action and the emissions savings from those projects are taken into consideration in the calculations. Projected savings are based on a set of growth targets for residents and businesses participating in the 100% renewable electricity purchasing program. These targets are as follows:

Year	Residential Growth Targets	Commercial Growth Targets
2025	30%	5%
2030	60%	10%
2035	70%	20%
2040	80%	30%
2045	90%	40%
2050	100%	50%

The user may opt to adjust the growth targets using Table 3b on the Dash by Action tab. Growth in the model is based on the number of households and business participating in the CCA program as of 2020 and the total number of residential and small commercial accounts in Cambridge from Eversource billing data. The growth is the difference between the two sources – i.e., the number of households and businesses that need to still be engaged to enroll 100% of the customers who

appear in the Eversource data. Emissions from growth beyond that (i.e., new construction) is covered by Action 2.1, Net Zero Requirement for New Construction.

Calculations

The calculation to determine the emissions savings from this action proceed as follows:

- The model first applies the residential and commercial program growth targets to the projected number of households and businesses in Cambridge. This provides an estimated number of participants each year.
- From the tracking data the average electricity consumption for residences and businesses is applied to the estimated numbers of participants each year to obtain a kWh consumption each year for both customer types.
- From there, the annual grid CO2e emissions factor is applied to the estimated participating kWh to determine the amount of emissions avoided by customers participating in the 100% renewable electricity purchasing program.

The annual CO2e reductions from this action is then determined as the sum of emissions avoided from the residential participant and the commercial participants.

APPENDIX H. Net Zero Task Force Meeting Materials

A key element ensuring the continued forward-thinking of the Net Zero Action Plan (NZAP) is the plan's mandate that a detailed review of the whole suite of actions be conducted every five years by a nominated Task Force. The 2021 NZAP update is the first such review conducted since the plan's adoption in 2015. In September 2020, a 25-person Task Force was appointed, comprising eight Residents/Advocates, eight Institutions/Property Owners/Developers, and nine Subject Matter Experts. Regular updates on the Task Force meetings were posted on the City's website at: www.cambridgema.gov/netzero.

The Task Force was convened via Zoom webinar for a total of five full-group Task Force meetings and six working-group Task Force meetings between November 12, 2020 and May 27, 2021.

The five full-group Task Force meetings were each two hours and included a 10-minute public comment period[19]. Meetings were planned and facilitated by City staff and the consultant team, which included DNV (technical/policy subject matter expert), Sorensen Partners (facilitation consultant), and AEC (equity consultant). Three initial full-group Task Force meetings were held from November 2020 to January 2021 to establish a common basis of understanding among the Task Force regarding:

- NZAP principles that guided the original NZAP and that should be used in this five-year review of the NZAP: current science, policy, technology, and equity conditions; and co-benefits impacts.
- Social and demographic existing conditions within the City that impact Equity, and that could have implications for the relative Equity that results from each of the existing and proposed NZAP Actions.
- GHG emissions trends in the current and potential future building stock of the City. Cambridge added 8.1 million square feet of floor area between 2015 and 2020, and yet emissions have remained flat.
- Technology trends – and economic feasibility of new technologies – with the potential to reduce GHG emissions in the built environment.
- Opportunities and challenges related to different energy sources, including electricity, rooftop solar, natural gas, and off-site renewables.
- Policy and regulatory changes at the local, state, and federal level that overlap with existing and proposed NZAP Actions.
- Key partnerships with other active organizations in the Cambridge educational and business community that are advancing agendas related to net-zero targets for existing and new infrastructure in the built environment.

[19] Meeting materials and recordings can be found here on the Cambridge Community Development Department website: https://www.cambridgema.gov/CDD/Projects/Climate/netzerotaskforce

In the first Task Force meeting, the consultant team presented the historical context for the development of the NZAP – its focus on buildings and renewable energy supply to buildings, a local carbon fund, communications, and capacity building – and the five-year update process. The Task Force reviewed the five Action categories in the NZAP; looked at GHG emissions community-wide; and discussed the NZAP's overarching focus – Cambridge's target of Carbon Neutrality by 2050, aligning with the United Nations and current science – as well as the trendline that shows we are not on track to achieving sufficient GHG reductions to meet the target. The proposed framework for evaluating NZAP goals and actions was also discussed in the contexts of science, policy, technology, and equity. Within the equity context, possible metrics for understanding equity impacts of NZAP actions were also covered. Discussion was held about components of equity, including public health benefits, data sources, and how to improve the differential benefits of NZAP actions for vulnerable populations.

In the second Task Force meeting, the consultant team presented on building sector GHG emission trends, including 2012-2019 results, and noting that commercial buildings are the largest source of emissions in the City, and that emissions are roughly split between natural gas consumption and electricity use. DNV then presented a five-year assessment of NZAP Actions and Impacts to-date.

During the three-initial full-group Task Force meetings – in order to create a forum for detailed and divergent discussion – breakout discussions were held during which Task Force members spent 15-20 minutes in discussion with a smaller group of participants. Question and answer sessions were moderated at multiple points during each meeting. Questions were frequently raised by Task Force members during the presentation of content, and Task Force members provided citations and links to technical and policy content within the Chat function of the Zoom webinar platform. The breakout discussions and the question-and-answer sessions were fruitful in giving Task Force members a forum to highlight issues of concern and potential refinements and modifications to the NZAP actions.

In the third Task Force meeting, the BEUDO Requirements (Action 1.2) were discussed extensively, based on the high ranking of BEUDO buildings in the year-over-year inventory of GHG emissions. BEUDO buildings – buildings that are larger than 25,000 square feet if they are commercial buildings and 50 or more units if they are residential buildings – account for approximately 70% of emissions in Cambridge, and number approximately 1,100 buildings in the City. The co-benefits of NZAP actions were also debated, and were augmented based on Task Force feedback to include consideration of additional aspirational co-benefits in Government and Policy Development, Economics, Environment, Health and Wellbeing, Climate Resilience, and Access and Engagement that should be considered as the Task Force recommends adjustments to the NZAP actions. The consultant team also presented an overview of building technologies – including Thermal Tech, DER (Distributed Energy Resources), Energy Efficiency, Materials, Thermal Energy Supply, and Grid-Scale Renewables – as further context for how and what adjustments to the NZAP should be considered.

Following the three initial full-group Task Force meetings, it was determined that additional fine-grained discussion in smaller working groups would be useful in order to present and debate information and issues resulting in specific proposals to modify the NZAP actions.

Six working-group Task Force meetings were then convened from February to March 2021 following the third full-group Task Force meeting to hold extended discussion about proposed changes to Actions. Two meetings were held for each of three working groups organized by Task Force members providing input on the action areas of **Energy Efficiency in Existing Buildings, Net-Zero New Construction, and Energy Supply**. Each of these working-group Task Force meetings was facilitated by a City and consultant-led team of technical/policy subject matter experts from DNV.

Following the working-group Task Force meetings, the fourth and fifth full-group Task Force meetings were held in April and May 2021 to share the results of the working-group meetings and form a basis of agreement around proposed modifications to the NZAP. In the fourth meeting, each action in the NZAP with proposed modifications was presented by spokespersons from the working groups. All actions with proposed modifications were discussed sequentially. The proposed text changes to

the actions were presented in the meeting slides, and Task Force members asked questions and raised issues. Equity issues were also embedded in the design of all the action adjustments. Among the many topics discussed at this meeting, the Task Force focused specifically on how low and moderate income (LMI) multi-family housing tenants and landlords are considered in the NZAP action adjustments as was financing mechanisms.

Between the fourth and fifth meetings, Task Force members "voted" on the refined NZAP Actions presented in the fourth meeting through a poll created in the online platform Consider.it. Votes were categorized on a scale of strong disagreement to strong agreement. Additional comments were provided by Task Force members as they cast their votes, and comments from the Google Docs were added to the Consider.it poll so that all comments were available for review in one place. The feedback collected during this process is provided as **Appendix D**.

In the fifth (final) Task Force meeting, the Consider.it poll results were presented, and implementation priorities were discussed by the whole Task Force. The consultant team shared insights about the relative GHG Impacts, Resilience, Other Co-benefits, and Equity "ratings" of each of the proposed NZAP action adjustments. Through this conversation it was determined that focusing on the BEUDO Requirements as well as the Local Carbon Fund should be the highest priorities while those actions that have lesser impacts or community benefits such as increasing the green building requirements would be lower priority. The consultant team also shared the timeline showing how the NZAP actions may be implemented over time, from 2021 to 2030. The Task Force discussed the plan for implementation of the NZAP action adjustments, including key partnerships within the business and academic community.

For slides and recordings of each meeting, see the Presentations and Meeting Materials tab on https://www.cambridgema.gov/CDD/Projects/Climate/NetZeroTaskForce.

About DNV

DNV is a global quality assurance and risk management company. Driven by our purpose of safeguarding life, property and the environment, we enable our customers to advance the safety and sustainability of their business. We provide classification, technical assurance, software and independent expert advisory services to the maritime, oil & gas, power and renewables industries. We also provide certification, supply chain and data management services to customers across a wide range of industries. Operating in more than 100 countries, our experts are dedicated to helping customers make the world safer, smarter and greener.