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

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

renewables in the energy supply; however, there is much work to do to meet the city's net zero emissions goals.

- 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. 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.

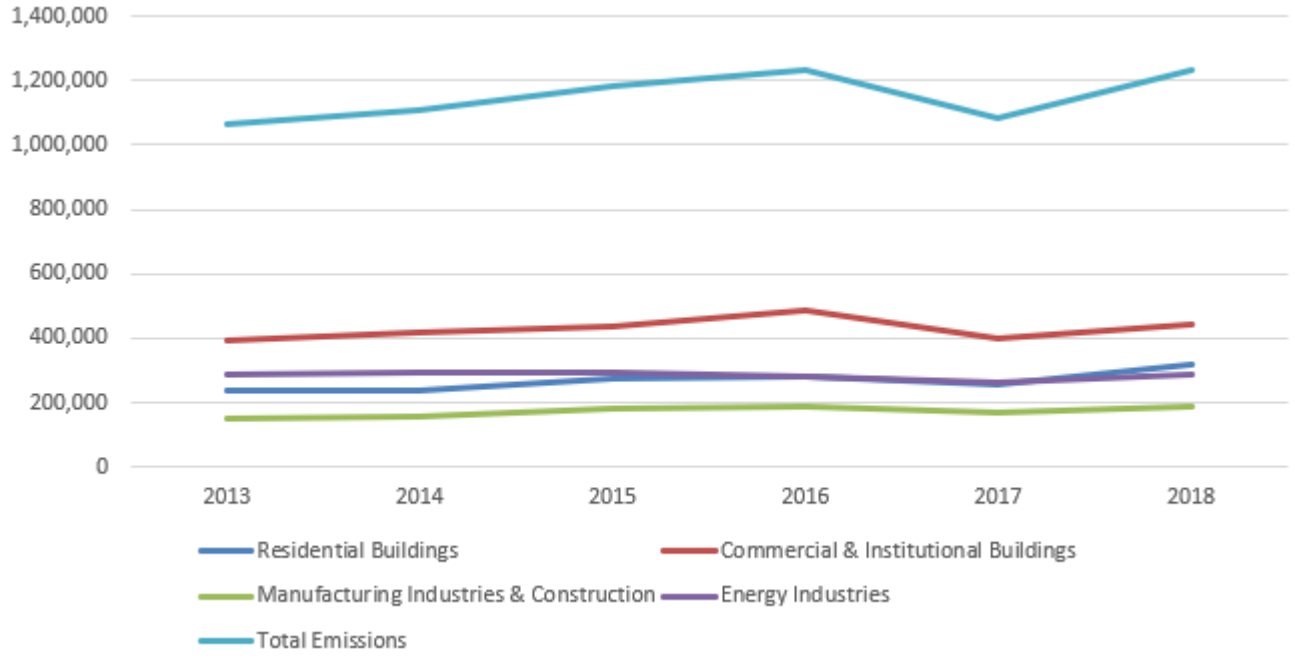
[2] Electric and gas consumption data only available through 2018 at the time of this report

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

Table 2-1: Building Sector CO2e emissions 2013-2018

Subsector	2013	2014	2015	2016	2017	2018
Residential	235,048	238,856	274,566	283,716	257,845	316,686
Commercial	393,834	418,732	436,854	484,353	398,032	444,086
Manufacturing	148,190	158,842	182,479	184,632	165,797	186,197
Energy Industries	285,983	292,670	291,395	279,246	260,315	288,743
Total	**1,063,055**	**1,109,100**	**1,185,294**	**1,231,946**	**1,081,990**	**1,235,712**

Figure 2-1: Building Sector Emissions Trends 2013-2018

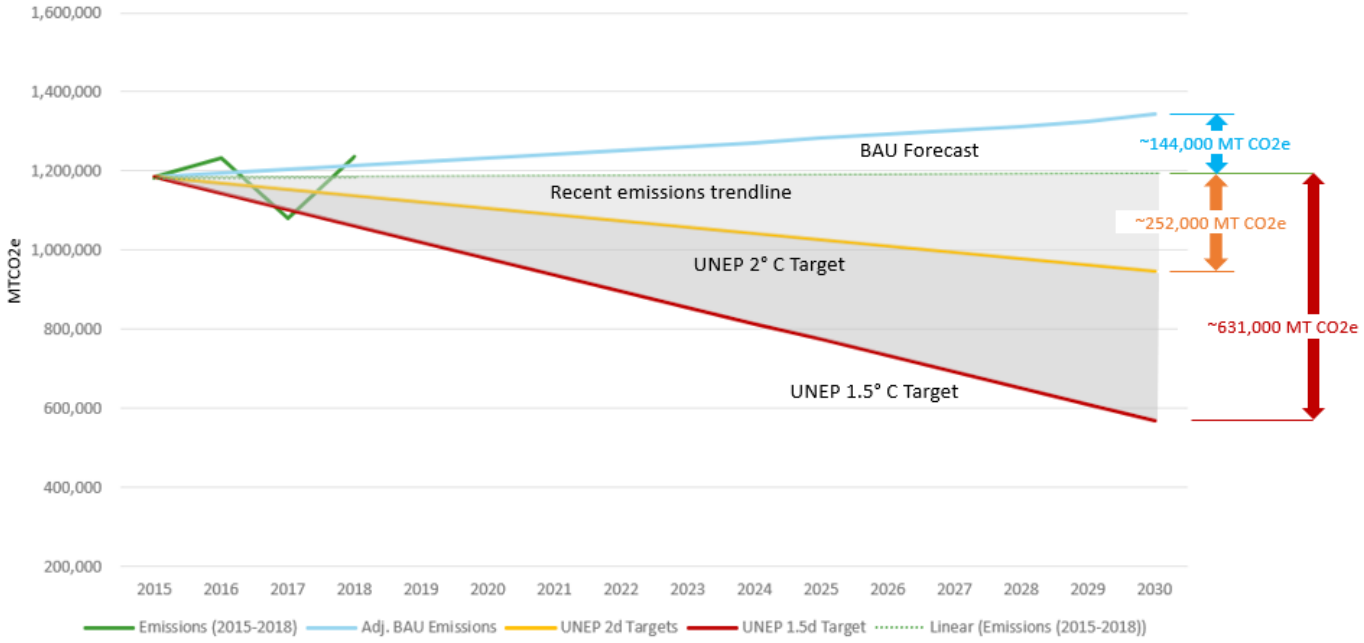


To provide more context, a comparison was done of the recent emissions trends to what was anticipated in NZAP planning models. When comparing what was forecasted for year-over-year emissions reductions in the NZAP Model (adjusted to 2014 actual emissions) with the actual emissions over the same time 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.

If long-term goals or targets are taken into consideration with respect to recent trends, it can be observed that if the same trends continue through 2030, the city will fall far short of its goals. As a demonstration of this, Figure 2-2 includes an extended recent emissions trendline along with targets set by the United Nation Environment Programme (UNEP) to remain within 2.0° C and 1.5° C temperature goals. While these are not

targets formally adopted by Cambridge, they do align with the Paris Agreement[4] and goals of the Global Covenant of Mayors for Climate and Energy[5], of which Cambridge is a signatory.

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



*UNEP targets based on global emissions scenarios (Source: UNEP, Lessons from a decade of emissions gap assessments (2019))

**The Adjusted BAU forecast is based on the Cambridge 2017 community-wide inventory and forecast (stationary energy sector only) adjusted to the 2015 NZAP emissions baseline.

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

[4] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

[5] https://www.globalcovenantofmayors.org/

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
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

Action No.	Action	Status as of 2020	Description	Stage	Next Steps	Relative GHG Impacts
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	Communication s Strategy		Implementation of multi-faceted communication strategy ongoing	Implementation	Action-specific and integrated stakeholder engagement activity	Supporting Action
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[6] program data and will continue through FY20 with a concierge service being established to better facilitate retrofit projects and connect building owners with resources

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

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 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

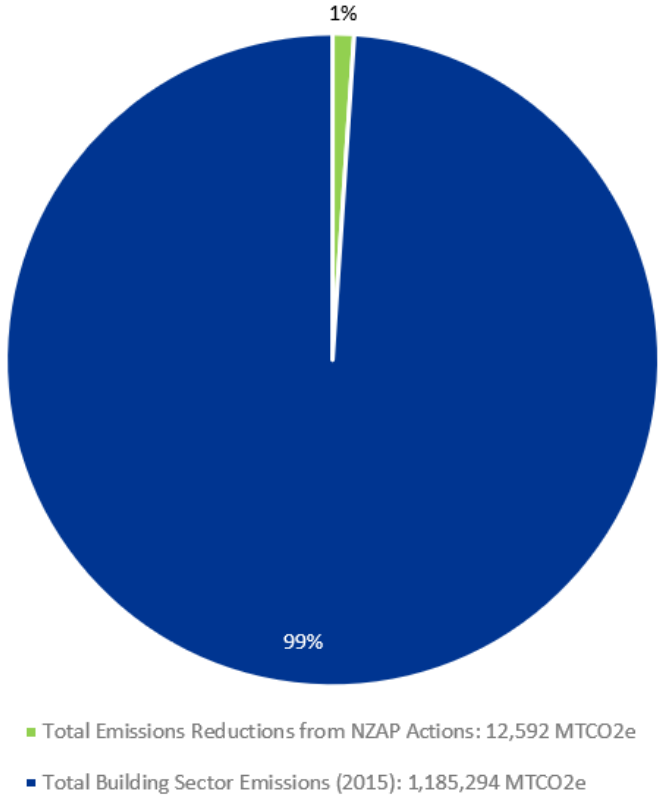
performance data only periodically (i.e., every five years) and improve the quality of future impact analyses. Consistent tracking and monitoring of data will also enable the city to more quickly take action and make adjustments if certain actions are not performing as expected.

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 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[7], 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.

[7] 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