Initiating an Existing Building Policy Ecosystem for Surrey

A Review of Six Leading Cities

Prepared by: Jiaxin Li, UBC Sustainability Scholar, 2018
Prepared for: Maxwell Sykes, Climate and Energy Manager, City of Surrey

August 2018

Table of Contents

INTRODUCTION **3**

Problem Statement and Solution Area 3

Purpose and Method 3

Report Overview 4

RESEARCH APPROACH **4**

Market Transformation Framework 4

Targets *5*

Data & Reporting *5*

Regulations *5*

Incentives *5*

Education & Training *6*

Case Study Cities 6

New York City *7*

Boulder *8*

Boston *8*

Seattle *9*

Chicago *10*

London *10*

Study Limitations 11

LESSONS LEARNED **11**

Targets 12

Data & Reporting 14

Regulations 17

Compliance Coverage *19*

Implementation Timeline *20*

Enforcement Action *20*

Incentives 20

The Percentage of a Project Cost *21*

Prescriptive Rebate *21*

Performance-Based Rebate *21*

Education & Training 23

Market Awareness *23*

Regulatory Compliance *23*

Skills Development *24*

Summary of Lessons Learned 24

RECOMMENDATIONS FOR SURREY **25**

FUTURE RESEARCH RECOMMENDATIONS **25**

APPENDIX A:

MAPPING ENERGY EFFICIENCY POLICIES AND PROGRAMS FOR EXISTING BUILDINGS **27**

Introduction

Problem Statement and Solution Area

Climate change poses a fundamental challenge to our generation, and the most significant driver of the current global warming trend is greenhouse gas (GHG) emissions from human activities since the mid-20th century.[1] Worldwide, the building sector accounts for approximately one-third of annual GHG emissions, and these emissions may double or even triple in the next 30 years if nothing is done.[2] In Canada, it is the third largest emissions source.[3]

Improving energy efficiency and reducing GHG emissions from buildings has gained increasing attention in recent years. However, there is no "one-size-fits-all" strategy for both new construction and existing buildings (i.e. buildings that already exist). Energy efficiency measures are less expensive and simpler when done during the construction process of a new building.[4] The high upgrade cost, tenants' resistance to disruptive processes and poor maintenance culture of building owners make the existing building stock one of the most critical and difficult GHG reduction challenges for cities.[5] These challenges are made more difficult by the large number of buildings that need to be retrofitted over the coming decades. To tackle this problem, cities and other levels of government need to establish a set of policies and programs that support a systematic, cost-effective, and long-term retrofit strategy to decarbonize existing buildings.

Purpose and Method

The City of Surrey has demonstrated its commitment to respond to climate change. Surrey aims to achieve 80 percent reduction in GHG emissions per capita by 2050 (below 2007 levels). As the building sector contributes to the majority of citywide energy consumption, and the city will continue to see an increase in its population, reducing GHG emissions and improving the energy efficiency in existing buildings is critical to reach this target.[6]

---

[1] Climate Change 2013: The Physical Science Basis. (2013). Retrieved from http://www.ipcc.ch/report/ar5/wg1/

[2] 2014: Buildings. In: Climate Change 2014: Mitigation of Climate Change. (2014). Retrieved from https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter9.pdf

[3] Where Do Canada's Greenhouse Gas Emissions Come From? (2018). Retrieved from http://prairieclimatecentre.ca/2018/03/where-do-canadas-greenhouse-gas-emissions-come-from/

[4] Sajip, J. Energy Efficiency: Good for Existing Buildings, Even Better for New Constructions. Retrieved from https://www.ny-engineers.com/blog/energy-efficiency-in-new-constructions

[5] ERNEST, K., ANKOMAH, E., TENGAN, C., & ASAMOAH, R. (2016). CHALLENGES TO RETROFITTING AND ADAPTATION OF EXISTING BUILDING WITHIN THE MAJOR CENTRAL BUSINESS DISTRICT IN GHANA. Retrieved from https://www.researchgate.net/profile/Ernest_Kissi/publication/313873905_CHALLENGES_TO_RETROFITTING_AND_ADAPTATION_OF_EXISTING_BUILDING_WITHIN_THE_MAJOR_CENTRAL_BUSINESS_DISTRICT_IN_GHANA/links/58ac4ed0a6fdcc0e079e43a1/CHALLENGES-TO-RETROFITTING-AND-ADAPTATION-OF-EXISTING-BUILDING-WITHIN-THE-MAJOR-CENTRAL-BUSINESS-DISTRICT-IN-GHANA.pdf

[6] Community Energy & Emissions Plan. (2013). Retrieved from https://www.surrey.ca/files/CommunityEnergyEmissionsPlan.pdf

Currently, several leading cities across the world are implementing innovative and effective policies and programs including: New York City, Boulder, Boston, Seattle, Chicago, and London. This study aims to further develop a "policy ecosystem framework" that the City of Surrey can use to systematically reduce GHG emissions from the existing building stock by summarizing the multi-pronged strategies these leading cities are taking through the market transformation lens.[7]

Report Overview

The first section of this report will briefly introduce the research approach this study used, setting the groundwork for the following analysis. The second section will discuss lessons learned from selected leading cities. In the third section, this report will focus on recommendations for Surrey to move forward. The final section identifies further research areas.

Research Approach

This chapter reviews the analytical framework and applies it to selected cities, in order to identify lessons that can be replicated in the City of Surrey.

Market Transformation Framework

Market transformation of a City's building energy system involves large-scale, lasting changes in energy sources, delivery, consumption, and related behaviors and decision-making. This study takes a market transformation framework initially developed for *Clean Energy DC.*[8] It includes five essential elements: targets, data & reporting, regulations, incentives, and education & training.

These five elements work in concert to support market transformation. For example, clear targets for energy and GHG emissions spur a government's efforts to establish policies and programs towards achievement. To ensure targets are adequate and achievable, they should be determined based on data-driven analysis. Data & reporting also helps evaluate targets in sight and make information accessible to the public. However, deep emissions reductions may not be likely to happen without a clear pathway set through codes and regulations. Incentives and education & training programs are essential to facilitate market actors to overcome financial or non-financial barriers and tackle any substantial knowledge deficits. These are some, but not all, of each element's role in market transformation and relationship to other

[7] The framework was initially outlined for broader energy system transformation by Dave Ramslie of Integral Group, and applied as part of the development of the District of Columbia's Clean Energy DC energy and emissions strategy.

[8] Clean Energy DC | ddoe. Retrieved from https://doee.dc.gov/cleanenergydc

elements. These elements are further explained below, in the context of municipal climate action on existing buildings.

Targets

Achievable quantitative outcomes with a specific timeframe for cities and existing buildings. Targets help drive a city to design energy efficiency policies and programs. For example, Chicago commits to reducing 4.6 $MMTCO_2e$ GHG emissions in the building sector by 2020, contributing to 30 percent of total carbon reductions. The city then outlines 8 actions for stakeholders in the market to reach this target.[9]

Data & Reporting

Quantitative and qualitative data and information used for analysis and to inform policy, planning, and program decisions and design. Cities collect various types of data (energy usage, basic building information, and energy system), benchmark quantitative data and make public disclosure. The data is used to measure the energy performance of buildings, facilitate the operation of projects, evaluate energy-related decisions and develop strategic, effective, and cost-effective policy and programs, e.g., Boston collects different types of data from documents & records, the Benchmarking Ordinance, and the Mayor's Carbon Cup. By using data collected, the city develops the GHG emissions inventory, reports benchmarking results annually, visualizes datasets through the Ordinance Compliance Map.

Regulations

Official rules established by a municipal government. Cities use regulations to enforce energy saving actions and ensure minimum standards of building design and operation in existing buildings, e.g., The Seattle Existing Building Code (SEBC) sets minimum requirements for alteration, addition, change of occupancy, repair, and relocation of existing buildings.[10] The city also adopted The Energy Benchmarking Policy and The Tune-Ups Policy, requiring affected building owners to report their annual energy consumption data, conduct an energy assessment, and implement corrective actions.

Incentives

Financial and non-financial approaches intended to incite desired actions. Cities provide rebates, share the percentage of project costs, offer free technical guidance and other forms of incentives for decision makers in the market. These incentives help reduce upfront cost and balance out a perceived or real barrier, increasing the

[9] Chicago Climate Action Plan – Energy Efficiency Buildings. (2008). Retrieved from http://www.chicagoclimateaction.org/filebin/pdf/finalreport/EnergyEfficientBuildings.pdf

[10] Existing Building Code - Seattle. Retrieved from http://www.seattle.gov/dpd/codesrules/codes/existingbuildingcode/

adoption of prioritized technologies and energy efficiency measures in existing buildings. e.g., London's RE: NEW program is designed to provide free energy audits for homeowners, laying the foundation for further home energy upgrades.

Education & Training

The process of acquiring theoretical knowledge and developing specific skills.
Education and training programs help stakeholders learn the knowledge and skills required to understand and implement energy efficient designs and energy conservation behaviors. e.g., NYC organized a series of public webinars on heating oil conversion and three basic hands-on training programs for building owners or managers, operators, and maintenance staff to diagnose potential energy and water efficiency programs and implement simple solutions in their buildings.[11]

Case Study Cities

This research reviewed critical energy efficiency programs and policies in six selected leading cities: New York City, Boulder, Boston, Seattle, Chicago, and London (UK). These cities were selected based on the project supervisor's experience and knowledge of the building policy landscape, as well as the City Energy Efficiency scorecard provided by The America Council for an Energy-Efficient Economy (ACEEE).[12] This section briefly introduces strategies undertaken by each city.

Table 1 summarizes a set of local context variables for the six case study cities and Surrey that may affect the impact of a given policy or program. These variables include regulation over energy market, energy prices and rate treatment, and home value of. Although evaluating the influence of these characteristics on the lessons learned was outside the scope of this study, Surrey should consider how these variables affect the replicability of specific policies and programs in the case study cities and lessons from these cities accordingly.

[11] Ways to Save | NYC Retrofit Accelerator | Green O&M Training Hub. Retrieved from https://retrofitaccelerator.cityofnewyork.us/resources

[12] The City Energy Efficiency Scorecard. (2017). Retrieved from http://aceee.org/local-policy/city-scorecard

Table 1: Overview of Local Context Variables

	New York City	Boulder	Seattle	Boston	Chicago	London	Surrey
Regulatory Context	R = Regulated D = Deregulated						
Electricity	D	R	R	D	D	D	R
Natural Gas	D	D	R	D	D	D	D
Energy Prices and Rate Treatment							
Natural Gas Price ($/GJ)	14.55	6.95	9.41	13.06	7.68	10.41	1.55
Electricity Price ($/kWh)	0.198	0.11	0.084	0.149	0.157	0.17	0.088
Seasonal Electricity Rates	Yes	Yes	No	Yes	No	No	No
Time-Of-Use Electricity Rates	Yes	Yes	Yes	No	Yes	Yes	No
Median Home Value Per Sq. Ft	$269	$332	$291	$259	$145	$2,081	$455

Note: Natural gas price are from U.S. Energy Information Administration (2018), GOV.UK (2018), FortisBC (2018); Electricity price are from Electricity Local (2018), GOV.UK (2018), BC Hydro (2018); Home value are from Zillow (2018), Office for National Statistics UK (2017), Numbeo (2018)

New York City

In New York City (NYC), existing buildings account for nearly 70% of the citywide GHG emissions.[13] As a leader in sustainability, the city has gone to great lengths to implement innovative plans in the building sector. In 2014, the city committed to reducing 60 percent GHG emissions from all existing buildings below 2005 level by 2050.[14]

To achieve its aggressive reduction target, NYC enacted the Greener, Greater Buildings Plan, a comprehensive set of building energy regulations supplemented by incentives, financing, and training opportunities.[15] The city also set a timeline to phase out heavy heating oil use. Local law 43 requires all buildings burning No.4 heating oil must convert to cleaner fuels by 2030.[16]

To help building owners comply with above regulations, NYC developed the NYC Retrofit Accelerator Program, a one-stop shop with incentives, personalized advisory services, and free resources. In partnership with diverse stakeholders, the NYC Carbon Challenge guides and motivates voluntary action towards reducing GHG emissions. According to its annual GHG emissions report, the city is on track to meet its emissions reduction target.

[13] Inventory Of New York City Greenhouse Gas Emissions In 2015. (2017). Retrieved from https://www.dec.ny.gov/docs/administration_pdf/nycghg.pdf

[14] One City Built to Last. (2014). Retrieved from http://www.nyc.gov/html/builttolast/assets/downloads/pdf/OneCity.pdf

[15] GBEE - Greener, Greater Buildings Plan. Retrieved from http://www.nyc.gov/html/gbee/html/plan/plan.shtml

[16] Local Law 43: NYC Clean Heat. (2010). Retrieved from http://www.nyc.gov/html/dep/pdf/air/ll43.pdf

Boulder

In the City of Boulder, 3,700 commercial and industrial buildings and 44,000 residential buildings account for approximately two-thirds of the total energy consumption and over 90% of the energy is generated by fossil fuels.[17] Therefore, improving energy efficiency in the building sector becomes the city's primary focus. To lead the way, Boulder has demonstrated its commitment to transforming all existing buildings to high-performance buildings by 2050, which will contribute a 16% reduction in citywide emissions.[18]

Under the Boulder Building Performance Ordinance, large commercial and industrial buildings should measure and publicly disclose their annual energy data, conduct energy audits and retro-commissions, and upgrade lighting systems.[19] To support effective implementation, Boulder provides online training for energy audits and retro-commissioning service providers to understand the city's specific requirements and compliance steps. Additionally, the city enacted the SmartRegs Ordinance in 2011 and became the first city in the nation to require a minimum level of energy performance for rental properties.[20]

Boulder received a $12 million grant from the U.S. Department of Energy's (DOE) Better Buildings initiative and used it to create and incentivize the EnergySmart program.[21] Energy advisors of the program provide free phone-advising services and connect homeowners to qualified contractors. To assist homeowners with upgrades, rebates and low-interest loans are also available through the program.

Boston

In Boston, a large percentage of carbon emissions is concentrated in a small number of large buildings and institutions (LBI), accounting for about 50 percent of citywide GHG emissions. Thus, the city aims to achieve a 25 percent reduction in carbon emissions from the LBI sector by 2020 (below 2005 levels).[22]

---

[17] Boulder's Climate Commitment. (2017). Retrieved from https://www-static.bouldercolorado.gov/docs/City_of_Boulder_Climate_Commitment_5.9.2017-1-201705091634.pdf?_ga=2.230384415.2001682129.1527280993-697694783.1526569555

[18] Boulder's Climate Commitment. (2017). Retrieved from https://www-static.bouldercolorado.gov/docs/City_of_Boulder_Climate_Commitment_5.9.2017-1-201705091634.pdf?_ga=2.230384415.2001682129.1527280993-697694783.1526569555

[19] Boulder Building Performance. Retrieved from https://bouldercolorado.gov/sustainability/boulder-building-performance-home

[20] M. Clevenger, a., & A. Martinez, L. (2017). Case Study for Meeting SmartRegs Requirements for Prescriptive and Performance Pathways in Boulder, Colorado. Retrieved from https://ascelibrary.org/doi/pdf/10.1061/%28ASCE%29AE.1943-5568.0000246

[21] Arena, L., & Vijayakumar, G. (2012). Evaluation of Boulder, CO, SmartRegs Ordinance and Better Buildings Program. Retrieved from https://www.nrel.gov/docs/fy12osti/54724.pdf

[22] Greenovate Boston 2014 Climate Action Plan Update. (2014). Retrieved from https://www.boston.gov/sites/default/files/greenovate_boston_2014_cap_update.pdf

The city has made significant progress to improve energy efficiency and renewable energy adoption in the building sector since 2007.[23] The Building Energy Reporting and Disclosure Ordinance requires affected buildings to report their energy and water consumption data annually and complete an energy assessment ***OR*** perform energy-saving actions once every five years.[24] Besides, Boston partners with Mass Save, a collaborative of Massachusetts's energy utilities and energy efficiency service providers, to provide free energy audits for Boston residents through the Renew Boston Energy Efficiency Program. Cash rebates are also available for deep retrofit projects.

Boston is poised to be the first city in the nation to establish a bankable finance model for energy efficiency projects.[25] The city identifies that technical and financial uncertainty are two critical barriers that prevent potential loan investors to finance energy efficiency projects. Therefore, the city designs the Renew Boston Trust program, an innovative financing model, incorporating performance guarantees for qualified retrofitting projects. A large number of existing buildings are expected to benefit from this model.

Seattle

In Seattle, 32 percent citywide GHG emissions come from existing buildings. The city has promised to cut 39 percent building energy emissions from 2008 levels by 2030 and aspires to be carbon neutral by 2050. As a key leader in climate action, Seattle uses stringent building regulations and various incentives to spur energy efficiency improvements.[26]

The city has a new building code, existing building code, and energy code. Buildings affected by the Energy Benchmarking Policy represent about two-thirds of the citywide commercial and industrial building area.[27] Seattle also has a Building Tune-Ups Ordinance requiring affected buildings to conduct an energy assessment and implement corrective actions starting from 2019. Municipal buildings lead by example, going beyond the minimum requirements of both policies.

The city and local utilities work together to provide an incentive program: Building Tune-Up Accelerator, assisting affected buildings to comply with the Building Tune-Ups Ordinance in advance of proposed deadlines. The city also cooperates with Mitsubishi to offer cash rebates for replacing oil-fired heating systems with electric heat pumps. For income-qualified households and multifamily buildings, the

[23] Greenovate Boston 2014 Climate Action Plan Update. (2014). Retrieved from https://www.boston.gov/sites/default/files/greenovate_boston_2014_cap_update.pdf

[24] Building Energy Reporting and Disclosure Ordinance. (2018). Retrieved from https://www.boston.gov/environment-and-energy/building-energy-reporting-and-disclosure-ordinance

[25] Renew Boston Trust » Sustainability » Boston University. Retrieved from http://www.bu.edu/sustainability/renewbostontrust/

[26] Seattle Climate Action April 2018. (2018). Retrieved from http://durkan.seattle.gov/wp-content/uploads/2018/04/SeaClimateAction_April2018.pdf

[27] Building Energy Benchmarking Analysis Report 2013 Data. (2015). Retrieved from http://www.seattle.gov/Documents/Departments/OSE/EBR-2013-report.pdf

HomeWise Weatherization Program provides free energy conservation measures, saving homeowners' energy costs and increasing comfort.

Chicago

In Chicago, the building sector is a priority of reductions as it contributes to roughly 70 percent of total GHG emissions. The city pledges to retrofit half of its building portfolios by 2020, accounting for 30 percent of total Chicago carbon emissions reduction.[28]

The Chicago Energy Benchmarking Ordinance requires large buildings to report their energy use annually and have the data verified once every three years. Affected buildings account for approximately 20 percent of citywide carbon emissions[29]. The city also added a new energy rating system in 2017, requiring building owners to post their rating and share this information when the property is listed for lease or sale. According to the benchmarking report that the city disclosed in 2017, GHG emissions from affected buildings fell by 19 percent from 2015 to 2017.[30]

Both online and in-person training is available to help building owners comply with the Benchmarking Ordinance. In 2018 spring, the city, along with nonprofit partners, organized three online webinars and a hands-on office hour.[31] Peer learning in the Retrofit Chicago Energy Challenge program serves as another education strategy. Through network events, quarterly engineering roundtables, and program awards, best practices are freely shared for building owners to overcome common barriers and learn from the successes.

Furthermore, the city develops a cross-sector collaborative model, uniting public and private entities to provide free energy audits, cash rebates, financing support, and technical assistance for residential and commercial buildings through the Retrofit Chicago Residential Partnership and the Retrofit Chicago Energy Challenge program. Moreover, the "Solar Chicago" bulk purchase program offers discounted rooftop solar systems to accelerate the renewable energy development in the city.

London

Residential and commercial buildings account for approximately 78 percent of carbon emissions in London, and 80 percent of these existing buildings will still be in place in 2050. Therefore, improving energy performance in existing buildings plays an

---

[28] Chicago Climate Action Plan. Retrieved from http://www.chicagoclimateaction.org/filebin/pdf/finalreport/CCAPREPORTFINALv2.pdf

[29] 2017 Chicago Energy Benchmarking Report. (2017). Retrieved from https://www.cityofchicago.org/content/dam/city/progs/env/EnergyBenchmark/2017_Chicago_Energy_Benchmarking_Report.pdf

[30] Ibid, 29.

[31] City of Chicago: Chicago Energy Benchmarking Free Training & Building Support. Retrieved from https://www.cityofchicago.org/city/en/depts/mayor/supp_info/chicago-energy-benchmarking/Chicago_Energy_Benchmarking-Training.html

essential role in achieving London's ambitious citywide target to cut 60 percent GHG emissions below 1990 levels by 2025 and 80 percent by 2050.[32]

To address the absence of energy data, the city designs the Business Energy Challenge (BED), a voluntary competition awarding efforts to reduce energy use in commercial buildings. This program helps generate energy data on London's commercial building stock through the self-reporting mechanism. London also provides every participant a benchmarking report card showing them the comparison of carbon intensity performance of an individual business with peers.[33]

The city provides free energy assessments and energy efficiency upgrades for private homes through the RE: NEW program. For fuel-poor Londoners, the city develops the Warmer Homes program to install heating and insulation measures with no charge. Furthermore, households and small businesses can purchase PV panels at a lower price through the City's group-buying Solar Together program. The city also creates a £450,000 Energy Leap program as a template for net-zero energy retrofitting projects.

Study Limitations

Before presenting the key findings, some limitations of this study should be mentioned. First, due to limited access and time, all the information used in the following analysis come from online government documents. The accuracy and completeness of the information obtained depend mainly on selected cities' updates. Second, there is little prior research using the market transformation framework and some policies and programs studied are not fit for this framework. Therefore, this study uses an exploratory research design.

Lessons Learned

This section discusses the lessons learned from reviewing 39 initiatives in six selected case study cities. Findings are structured around the five components of the market transformation framework introduce above: targets, data & reporting, regulations, incentives, and education & training. See Appendix A for the matrix: Mapping Energy Efficiency Policies and Programs for Existing Buildings. The matrix provides a simple overview of how the case study cities' programs and policies match up with the transformation framework.

[32] Energy in buildings. Retrieved from https://www.london.gov.uk/what-we-do/environment/energy/energy-buildings

[33] Urban Efficiency II: Seven Innovative City Programmes for Existing Building Energy Efficiency. (2017). Retrieved from https://issuu.com/c40cities/docs/urbanefficiencyii_final_hi_res__1_

Targets

Table 2 summarizes GHG emissions reduction targets set by governments. Beginning from the left, as can be expected, all six cities have quantitative targets with a baseline year and timeframe for citywide GHG emissions reduction. For example, New York City (NYC) aims to reduce at least 80 percent GHG emissions below 2005 (baseline year) levels by 2050 (timeframe).[34]

Surveyed cities further detail reduction targets for the building sector. According to the Chicago Climate Action Plan, improving energy efficiency in buildings will account for 30 percent of Chicago GHG reductions by 2020.[35] Boulder not only quantified emissions reduction from its building sector but also provided a qualitative description of the high-performance buildings it aims to transform all existing buildings to by 2050.[36] In addition to carbon reduction targets, Boston and London set targets for the number of home energy audits and energy upgrades.

Finally, it is interesting to note that three cities have set targets for specific programs or policies. For instance, London aims to retrofit at least 40 percent of its municipal buildings by 2025 through the RE: FIT program.[37] Boulder's Climate Commitment includes a target to achieve 100 percent compliance in SmartRegs by 2019.[38] Although these targets only capture part of the whole energy efficiency strategy, they are beneficial in driving certain actions.

Table 2: Government GHG Emissions Reduction Targets

CITY	CITYWIDE TARGET	BUILDING SECTOR TARGET	TARGETS FOR SPECIFIC PROGRAMS OR POLICIES
New York City	◉	◉	◉
Boulder	◉	◉	◉
Seattle	◉	◉	
Boston	◉	◉	
Chicago	◉	◉	
London	◉	◉	◉

Moving on to the process of establishing a target, all six cities adopted a top-down approach, setting a citywide GHG emissions reduction target first, with subsidiary

---

[34] One City Built to Last. (2014). Retrieved from http://www.nyc.gov/html/builttolast/assets/downloads/pdf/OneCity.pdf

[35] Chicago Climate Action Plan – Energy Efficiency Buildings. (2008). Retrieved from http://www.chicagoclimateaction.org/filebin/pdf/finalreport/EnergyEfficientBuildings.pdf

[36] Boulder's Climate Commitment. (2017). Retrieved from https://www-static.bouldercolorado.gov/docs/City_of_Boulder_Climate_Commitment_5.9.2017-1-201705091634.pdf?_ga=2.230384415.2001682129.1527280993-697694783.1526569555

[e] C40: Cities100: London - Large-scale Building Retrofits Reduce Emissions. (2015). Retrieved from https://www.c40.org/case_studies/cities100-london-large-scale-building-retrofits-reduce-emissions

[38] Ibid, 36.

targets to drive actions at a sector or sub-sector level.[39] For example, the Chicago Climate Task Force first commissioned a scientific and economic analysis to determine what level of action is required. After picking a citywide target, a team of researchers evaluated the potential for achieving reductions in the three highest impact sectors — building stock, transportation systems, and energy infrastructure. The city finally settled on 26 emissions reduction actions which provide a pathway to that target.[40] This top-down approach ensures clear citywide direction but requires accurate estimation of the ability of sectors and ongoing progress tracking. (See the Data & Reporting section below for more details)

Cities also develop voluntary energy saving targets for the private sector to spur interest in and accelerate the uptake of building energy efficiency improvements. As shown in Table 3, three cities have developed leadership programs among residential, commercial, and institutional buildings to motivate and support voluntary commitment towards a quantitative energy efficiency target with a timeframe. One example is the Retrofit Chicago Energy Challenge. Participants of the Challenge commit to reducing energy consumption by at least 20 percent over 5 years.[41] NYC provides participants with more flexibility on targets, allowing them to decide on a unit for measuring GHG emissions intensity (CO_2e/sq.ft.; CO_2e/FTE; CO_2e/OH), a base year and reduction level.[42] It is worth noting that, three of four programs haven't set any minimum floor area thresholds for participation. Presumably, this relatively "open door" program design will engage a diverse representation of private sector buildings in that city.[43] However, it also imposes high requirements on systematic support from the government.

Table 3: Voluntary Efficiency Targets for The Private Sector

CITY	PROGRAM	BUILDING TYPE		SIZE THRESHOLD
		Residential	Commercial	
New York City	NYC Carbon Challenge	◉	◉	
Boston	Mayor's Carbon Cup	◉	◉	◉
Chicago	The Retrofit Chicago Energy Challenge	◉	◉	
	Chicago Renewable Energy Challenge	◉	◉	

[39] Setting energy efficiency targets. (2017). Retrieved from https://www.iea.org/publications/freepublications/publication/EnergyEfficiencyTargetsEnergyEfficiencyInsightsBrief.pdf

[40] Chicago Climate Action Plan. Retrieved from http://www.chicagoclimateaction.org/filebin/pdf/finalreport/CCAPREPORTFINALv2.pdf

[41] About the Retrofit Chicago Energy Challenge. Retrieved from http://www.retrofitchicago.net/about

[42] NYC Carbon Challenge for Commercial Owners and Tenants Program Design. Retrieved from http://www.nyc.gov/html/gbee/downloads/pdf/NYC_Carbon_Challenge_for_Commercial_Owners_and_Tenants_Program_Design.pdf

[43] Urban Efficiency II: Seven Innovative City Programmes for Existing Building Energy Efficiency. (2017). Retrieved from https://issuu.com/c40cities/docs/urbanefficiencyii_final_hi_res__1_

Data & Reporting

Table 4 indicates three main types of data collection mechanisms observed, including documents & records, benchmarking regulations, and programs with a data reporting requirement.

All surveyed cities gather sub-regional energy usage (electricity, natural gas, and other fuels) data from city records, state and federal agencies' reports, and utility companies to develop GHG inventories, supporting climate action planning. This data collection technique depends largely on data accessibility and engagement of utility stakeholders. From 2011 to 2014, Boulder was unable to complete its GHG inventories because of limited access to energy consumption data. Following successful lobbying efforts, the Colorado Public Utilities Commissions agreed to provide the city with data necessary, enabling Boulder to rebuild its GHG inventory in 2015.[44]

Benchmarking regulations are used in five of six cities. Under these initiatives, owners of large residential and commercial buildings are required to submit basic building information and energy consumption data to cities annually. All five cities have adopted ENERGY STAR Portfolio Manager®, the online energy measurement and tracking tool designed by the U.S. Environmental Protection Agency (EPA), as the foundation for collecting building performance ratings.[45] Additionally, utilities in all five cities offer aggregated energy usage data for building owners upon request. In NYC, Boulder, Boston, and Seattle, building owners can also authorize utilities to upload required data automatically into Portfolio Manager. A significant barrier of benchmarking policies is that owners of multi-tenant buildings may not have access to sub-metered energy consumption data. It is the exact function that utility data aggregation is designed to carry out.

Table 4: Data Collection Mechanisms

CITY	DATA COLLECTION MECHANISM		
	Documents & Records	Benchmarking Regulations	Programs with A Data Reporting Requirement
New York City	◉	◉	◉
Boulder	◉	◉	
Seattle	◉	◉	
Boston	◉	◉	◉
Chicago	◉	◉	◉
London	◉		◉

[44] City of Boulder Community Greenhouse Gas Emissions Inventory. (2016). Retrieved from https://www-static.bouldercolorado.gov/docs/2016_Greenhouse_Gas_Emissions_Inventory_Report_FINAL-1-201803121328.pdf

[45] Use Portfolio Manager. Retrieved from https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager

Finally, cities with voluntary leadership programs require participants to report data counted toward their targets. As shown in Table 5, the data collection tool employed by NYC, Boston, and Chicago is the Portfolio Manager. Additionally, NYC provides each participant with a GHG Emissions Inventory Calculator that can automatically compute GHG emissions intensity and progress to date.[46] This design is mainly for small buildings that are not covered by the benchmarking policy as building owners in this size class are less familiar with the Portfolio Manager. Unlike the other three cities, London has designed an Excel spreadsheet to facilitate the data reporting process, addressing the absence of an industry standard tool for data collection in the U.K. Another notable feature is that data collection in most programs is annual, but the Retrofit Chicago Energy Challenge requires bi-annual reporting. With more frequent monitoring of progress, the city may have a better understanding of energy consumption behaviors, but program management costs and technical assistance needed to support participants also increase.

Table 5: Data Collection Details of Voluntary Leadership Programs

CITY	PROGRAM	DATA COLLECTION TOOL	COLLECTING PERIOD
New York City	NYC Carbon Challenge	GHG Emissions Inventory Calculator / Portfolio Manager	Annual
Boston	Mayor's Carbon Cup	Portfolio Manager	Annual
Chicago	The Retrofit Chicago Energy Challenge	Portfolio Manager	Bi-Annual
London	Business Energy Challenge	Custom Made Excel Spreadsheet	Annual

Along with data collection, Boston, Chicago, Seattle, and London take various approaches to improve the quality of reported data. Boston requires building owners to run an automated data check in Portfolio Manager, allowing them to fix errors before submitting reports to the city. Chicago asks for data verification conducted by a certificate holder. City staff in Seattle and London deploy data check after the initial data collection and contact owners of buildings with suspected data errors to make corrections.

Besides data collection, putting data into good use is also required to drive market transformation. All surveyed cities have developed GHG emissions inventories, allowing them to track progress against carbon reduction targets, understand emissions contribution by sector and energy sources, and design further strategy to reduce GHG emissions.[47] As mentioned above, inventories are based on the combination of direct data collected from documents and records and estimates for data that are not available. Table 6 indicates that five cities have followed the guidance of the Global Protocol for Community-Scale Greenhouse Gas Emission

[46] NYC Carbon Challenge for Commercial Owners and Tenants Program Design. Retrieved from http://www.nyc.gov/html/gbee/downloads/pdf/NYC_Carbon_Challenge_for_Commercial_Owners_and_Tenants_Program_Design.pdf

[47] Global Protocol for Community-Scale Greenhouse Gas Emission Inventories. Retrieved from https://ghgprotocol.org/sites/default/files/standards/GHGP_GPC_0.pdf

Inventory (GPC), an international standard to calculate and report citywide GHG emissions.[48] The ICLEI-US Format that Seattle adopted is the US counterpart to the global protocol. It provides a methodology tailored to US communities.[49]

Furthermore, four cities commit to conduct and report GHG inventories on an annual basis, while Seattle and Chicago have extended reporting periods. Note that NYC has a legal requirement to measure and disclose its GHG emissions data. In 2007, the city reported its first GHG inventory. Local Law 22 then came into effect in 2008, requiring NYC to update both the citywide and city government inventories annually.[50]

Table 6: Characteristics of GHG Emissions Inventories

CITY	METHODOLOGY	REPORTING PERIOD
New York City	GPC	Annual
Boulder	GPC	Annual
Seattle	ICLEI-US Format	Every three to four years
Boston	GPC	Annual
Chicago	GPC	Every five years
London	GPC	Annual

NYC, Seattle, Boston, and Chicago disclose building energy data collected from benchmarking policies annually by a spreadsheet on a government website. Note that Boulder has decided to publicly disclose data following a two-year grace period and 2016 is the first year of its benchmarking programs.[51] Thus, details of reporting are not available now.

Although public disclosure of data enhances transparency and gives stakeholders in the market easier access to the information, it will not drive actions only if market decision makers understand the data and incorporate it into their activities. However, data-heavy spreadsheets are too complicated for stakeholders to understand and use. To tackle this barrier, NYC, Seattle, Boston, and Chicago visualize datasets through a citywide energy map. It allows users to easily and quickly understand energy performance of a specific building. For instance, NYC's map provides data as well as a color chart in which blue represents a poor performer and yellow is for a high performer. Moreover, the map can inform users how a selected building is performing relative to other comparable buildings.[52] In addition to visualizing the benchmarking data, Boston also creates a map to track the hourly energy demand for

[48] GHG Protocol for Cities | Greenhouse Gas Protocol. Retrieved from https://ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities

[49] Greenhouse Gas Protocols - ICLEI USA. Retrieved from http://icleiusa.org/ghg-protocols/

[50] Inventory Of New York City Greenhouse Gas Emissions In 2015. (2017). Retrieved from https://www.dec.ny.gov/docs/administration_pdf/nycghg.pdf

[51] Boulder Building Performance 2015/2016 Report Program. Retrieved from https://www-static.bouldercolorado.gov/docs/Buildings-Performance-Report-Boulder-FINAL-1-201706010950.pdf?_ga=2.12561783.270457053.1531871339-697694783.1526569555

[52] Beddingfield, E., Hart, Z., & Hughes, J. How Cities are Using Building Energy Data to Drive Efficiency. Retrieved from https://www.imt.org/wp-content/uploads/2018/03/PuttingDatatoWork_SummaryReport.pdf

every building in the city. Using this information, Boston can assess the feasibility of potential energy generation and develop programs to transform its energy systems.[53]

Seattle, Chicago, and London also provide scorecards to individual building owners. Information on a scorecard varies among cities. Chicago's scorecard shows building energy performance that is evaluated through a four-star scale rating system. Additionally, building owners are required to post their rating in a prominent location and share this information when the property is for lease or sale.[54] While Information on a London's scorecard shows peer-building comparisons.[55] Seattle's one goes further to identify options for improvement and expected savings. Overall, these scorecards help building owners to recognize current issues and take actions.

In addition to communicating data to relevant industry actors, a city can further incorporate data into their outreach and engagement strategies. In NYC's Clean Heat, a program that guided and assisted buildings through clean fuel conversion process, the team targeted buildings that burned No.6 heating oil through data, contacted building owners and connected them to incentives and training programs.[56] Benefit from this data-based intervention, NYC has achieved 100 percent compliance with Local Law 43 and eventually phased out No.6 heating oil.[57]

Regulations

All surveyed cities have applied building codes to additions, alterations, and repairs of existing buildings. Requirements in building codes are designed to ensure that existing buildings meet their energy performance potential when renovations occur. In all six cities, provisions live for both residential and commercial buildings.

Table 7: Regulating Authorities and Compliance Path of Building Codes

CITY	REGULATING AUTHORITIES			COMPLIANCE PATH		
	Municipal	State	Federal	Prescriptive	Performance	Both
New York City	◉			◉		
Boulder	◉					◉
Seattle	◉					◉
Boston		◉				◉
Chicago	◉			◉		
London			◉		◉	

[53] BOSTON COMMUNITY ENERGY STUDY. (2016). Retrieved from http://www.bostonplans.org/getattachment/d52c36d5-2b1a-40e3-b4cd-3d4fa01ed4e6

[54] 2017 Chicago Energy Rating System. (2017). Retrieved from https://www.cityofchicago.org/content/dam/city/progs/env/EnergyBenchmark/2017_Chicago_Energy_Rating_System_Summary.pdf

[55] Urban Efficiency II: Seven Innovative City Programmes for Existing Building Energy Efficiency. (2017). Retrieved from https://issuu.com/c40cities/docs/urbanefficiencyii_final_hi_res__1_

[56] Brown, A., & Dragoo, K. (2016). Using Program Outreach to Advance Regulation and Drive Energy Efficiency. Retrieved from https://aceee.org/files/proceedings/2016/data/papers/2_779.pdf

[57] 100 Percent Phase Out Complete - New York City Buildings Say Goodbye to No. 6 Heating Oil. (2016). Retrieved from https://cooperator.com/article/new-york-city-buildings-say-goodbye-to-no-6-heating-oil/full

As shown in Table 7, regulating authorities vary from cities to cities. Building codes in NYC, Boulder, Seattle, and Chicago are set by local governments. Differently, Boston adopts energy code developed by Massachusetts and London implements building regulations established by the central government. Furthermore, there are three paths for compliance. Building codes in NYC and Chicago are prescriptive based, requiring each design element to meet a certain standard. On the contrary, London adopted a performance-based building code that targets at overall efficiency performance of a building. Boulder, Seattle, and Boston offer both options.

Regulations, other than building codes, that aim at improving energy efficiency in existing building are compiled into Table 8. Firstly, such regulations are noticeably lacking in London. Moreover, all the other five surveyed cities implement benchmarking policies, requiring building owners to submit necessary building information and energy performance data to local governments on an annual basis. Cities will then publicly disclose data collected on a public website, allowing building owners to understand the energy performance of their buildings. It is noteworthy that many cities use benchmarking policies to form other regulations towards lowering energy consumption, as discussed below.

Regulations for actions are widely observed across cities. Energy audits, which are surveys and analyses of energy consumption, and retro-commissioning, the process of ensuring building equipment and systems are functioning properly and together, help building owners in NYC, Boulder, Seattle, and Boston have a more robust understanding of their buildings.[58] Note that cities (NYC, Boulder, Boston) with energy audit requirement do not need building owners to implement any recommended improving measures. As for retro-commissioning, all three cities (NYC, Boulder, Seattle) require corrective actions. A possible reason for this difference is retro-commission helps identify operations and maintenance (O&M) measures for efficiency improvement and these measures are low cost or no cost in most cases so that it won't cause financial barriers for building owners. Another point that needs attention is that Boston offers more options for compliance. Owners of covered buildings can choose to complete either energy audits or at least one required energy actions such as installing renewable energy or conducting an upgrade project that reduces 15% annual energy use intensity.[59]

NYC and Boulder have also adopted regulations for improving lighting systems, requiring building owners to complete one-time lighting upgrades in compliance with specific standards. Additionally, NYC takes a step forward and requires owners of large commercial buildings to install electrical sub-meters for each tenant space greater than 5,000 square feet and share monthly energy statements.[60] NYC also

[58] GBEE - Greener, Greater Buildings Plan - LL87: Energy Audits & Retro-commissioning. Retrieved from http://www.nyc.gov/html/gbee/html/plan/ll87.shtml

[59] Building Energy Reporting and Disclosure Regulations. Retrieved from https://www.cityofboston.gov/images_documents/BERDO%20Regulations%20Approved%2018Dec2013_tcm3-42376.pdf

[60] GBEE - Greener, Greater Buildings Plan - LL88: Lighting Upgrades & Sub-metering. Retrieved from http://www.nyc.gov/html/gbee/html/plan/ll88.shtml

designed the Heating Oil Regulation. Existing buildings must phase out the use of No.6 and No.4 heating oil by 2030.[61]

Unlike the above regulations that only describe what must be done, Boulder's SmartRegs includes a performance-based approach, focusing on outcomes rather than each precise factor. Under this initiative, all licensed rental buildings must meet minimum energy efficiency standards. Buildings owners can either choose a prescriptive path (The SmartRegs Prescriptive Checklist) or a performance path (HERS index score of at least 120).[62] Although the performance path provides more flexibility in compliance, it is more time-intensive and costly. As a result, 98% of rental property owners choose the prescriptive one.[63]

Table 8: Overview of Regulations for Energy Efficiency in Buildings

	New York City	Boulder	Seattle	Boston	Chicago	London
Building Code	◉	◉	◉	◉	◉	◉
Benchmarking	◉	◉	◉	◉	◉	
Energy Audit	◉	◉		◉		
Retro-Commissioning	◉	◉	◉			
Lighting Upgrade	◉	◉				
Sub-Metering	◉					
Heating Oil	◉					
Basic Energy Efficiency Standard		◉				

Requirements vary by city, but there are three essential components of a regulation's design.

Compliance Coverage

Cities use the size threshold and building type to determine compliance coverage. For example, commercial and industrial buildings over 20,000 square feet are required to comply with the Boulder Building Performance Ordinance.[64] As shown in table 9, all benchmarking and action required regulations surveyed for this report aim for large residential and commercial buildings (greater than or equal to 20,000 square feet).

[61] Local Law 43: NYC Clean Heat. (2010). Retrieved from http://www.nyc.gov/html/dep/pdf/air/ll43.pdf

[62] The Rental Housing License Handbook + SmartRegs Guidebook. (2017). Retrieved from https://www-static.bouldercolorado.gov/docs/340-Rental-License-Handbook-1-201706211422.pdf?_ga=2.224469657.2001682129.1527280993-697694783.1526569555

[63] SmartRegs Inspection Information. Retrieved from https://bouldercolorado.gov/plan-develop/smartregs-inspection-information

[64] Boulder Building Performance. Retrieved from https://bouldercolorado.gov/sustainability/boulder-building-performance-home

Table 9: Compliance Size Threshold

	New York City	Boulder	Seattle	Boston	Chicago
Benchmarking	≥ 25,000 SF (R,C)	≥ 20,000 SF (C)	≥ 20,000 SF (R,C)	≥ 35,000 SF (R,C)	≥ 50,000 SF (R,C)
Energy Audit	≥ 50,000 SF (R,C)	≥ 20,000 SF (C)	≥ 50,000 SF (R,C)		
Retro-commissioning	≥ 50,000 SF (R,C)	≥ 20,000 SF (C)		≥ 35,000 SF (R,C)	
Lighting Upgrade	≥ 25,000 SF (R,C)	≥ 20,000 SF (C)			
Sub-Metering	≥ 25,000 SF (C)				

Note: R is residential building and C is commercial building

Implementation Timeline

A well-thought-out schedule allows building owners to be educated about their compliance obligations.[65] Boulder and Seattle choose to phase in their regulations based on building sizes. Under this approach, the largest buildings in a city are required to take actions first, following by relatively smaller buildings.

Enforcement Action

All surveyed cities use administrative fines to ensure compliance. Chicago set a fixed penalty for violations. Non-compliant building owners will be fined $100 and $25 for each day until they obey the benchmarking ordinance.[66] NYC's and Boulder's enforcement mechanisms define caps for penalties. For instance, NYC sets a fine up to $2,000 a year.[67] In Boston and Seattle, non-compliant building owners will be issued a warning letter first, providing them additional time for compliance, and fines are based on building size. Unlike other cities that only target at actions of building owners, Boston sets a penalty, up to $35 per day, for non-residential tenants who fail to provide building owners with their energy usage data.[68]

Incentives

Table 10 summarizes an array of incentives that surveyed cities applied to accelerate the market transformation. Incentives observed are available for both residential and commercial buildings and can be broadly grouped into financial and non-financial incentives. Three typical forms of financial incentives used by cities are:

[65] Benchmarking and Disclosure: Lessons from Leading Cities. (2012). Retrieved from https://www.abettercity.org/docs/06.2012%20-%20Benchmarking%20report%20-%20Final.pdf

[66] Enforcement (§ 18-14-101.5)—Chicago Decoded—Chicago Decoded. Retrieved from https://chicagocode.org/18-14-101.5/

[67] Buildings - Benchmarking. Retrieved from https://www1.nyc.gov/site/buildings/business/benchmarking.page

[68] Building Energy Reporting and Disclosure Regulations. Retrieved from https://www.cityofboston.gov/images_documents/BERDO%20Regulations%20Approved%2018Dec2013_tcm3-42376.pdf

The Percentage of a Project Cost

The percentages range from 20% to 75% in surveyed cities. Also, this type of incentive can be provided in different ways such as cash rebates, tax abatements, and direct purchasing cost reduction.

Prescriptive Rebate

Regardless of the cost, this incentive approach has one fixed amount.[69] Cities apply it not only for specific equipment but also towards the whole house energy efficiency improvement (See case examples in Table 9 for more details).

Performance-Based Rebate

Unlike the above two types of incentives that focus on energy-efficiency measures, this approach directly results in energy savings but is more complicated to administer as it requires an energy assessment process to ensure those who get incentives reach their projected energy savings.[70] Moreover, the design of thresholds is non-linear. In NYC's multifamily performance program, a building that achieves a 40% reduction in energy usage will receive $3,500 per unit, five times the amount for 20% savings.[71] Briefly, greater incentives are used to motivate people to go deeper.

An interesting finding is that cities use deadline and fixed quota in both financial and non-financial incentive design to create a sense of urgency and motivate building owners to take actions.[72] For instance, to qualify for the Boulder's EnergySmart rebates, building owners should complete energy upgrades between April 1, 2018, and June 30, 2018.[73] Seattle's Building Tune-Up Accelerator Program only recruited 100 participants[74]. London's Warmer Homes is a £2.5 scheme and on a first-come, first-served basis.[75]

It is also worth noting that Chicago uses the design of terms and conditions to raise awareness of incentives. In the Retrofit Chicago Residential Partnership program, a

---

[69] Designing Effective Incentives to Drive Residential Retrofit Program Participation (Text Version) | Department of Energy. Retrieved from https://www.energy.gov/eere/wipo/designing-effective-incentives-drive-residential-retrofit-program-participation-text

[70] Ibid, 69.

[71] Multifamily Performance Program: Existing Buildings. Retrieved from https://www.nyserda.ny.gov/All%20Programs/Programs/MPP%20Existing%20Buildings

[72] Proven Practices: Time-Limited Incentives | Residential Program Solution Center. (2016). Retrieved from https://rpsc.energy.gov/proven-practices/proven-practices-time-limited-incentives

[73] Whole Home Bundled Efficiency Rebates. (2018). Retrieved from http://www.energysmartyes.com/wp-content/uploads/2018/04/Stand-Alone-Eligible_Measures_for_ES-Q2CY18.pdf

[74] Building Tune-Up Accelerator Program - Environment | seattle.gov. Retrieved from http://www.seattle.gov/environment/climate-change/building-energy/building-tune-ups/tune-up-accelerator

[75] Warmer Homes. Retrieved from https://www.london.gov.uk/what-we-do/housing-and-land/improving-quality/warmer-homes

single-family homeowner can get an energy audit for free if he or she hosts a house party to share their experience of services with friends and neighbors.[76]

Table 10: Incentive Map

INCENTIVE	TYPE	CASE STUDY CITY EXAMPLE
Financial	The Percentage of a Project Cost	Boulder: Homeowners can receive 25% of a solar PV project cost up to $350.[77] NYC: The city provides a property tax abatement covering 20% of photovoltaic (PV) equipment costs.[78] Chicago Solar Express: This group buying program offers discounted solar installation less than 75% of the average market costs.[79]
	Prescriptive Rebate	Boston: Homeowners can save on the cost of a forced hot water boiler (≥ 90% AFUE rating) with a $ 1500 rebate.[80] Seattle: Participants of the Building Tune-Up Accelerator Program can get up to $0.03 per square foot for the tune-up assessment and $0.09 per square foot for corrective actions.[81]
	Performance-Based Rebate	NYC: Building upgrade projects that target a minimum of 40% energy savings will receive a $3,500 rebate per unit.[82]
Non-Financial	Free Technical Guidance	NYC Retrofit Accelerator: Program advisors work one-on-one with building owners to help them understand relevant regulations, find contractors, incentives, and financing, walk through every step of energy efficiency and clean energy improvements.[83]
	Free Energy Assessment and Improvements	London's Warmer Homes: Income-qualified homeowners can receive up to £4,000 worth of home energy efficiency improvements, including an energy audit, wall insulation, improved heating systems, etc.[84]
	Awards and Public Recognition	Retrofit Chicago Energy Challenge: The achievements of participants are promoted and recognized through the annual awards ceremony, official websites, newspaper advertisements, and regular mayoral press releases.[85]
	Extra Floor Area and Structure Height	Seattle's Living Building Pilot Program: Buildings that achieve the living building certification or meet specific requirements can get 15% more floor area 10-20 feet additional structure height depending on the height limit in a zone.[86]

[76] City of Chicago: Retrofit Chicago Residential Partnership FAQs. Retrieved from https://www.cityofchicago.org/city/en/progs/env/retrofit-chicago-faqs.html

[77] EnergySmart Residential Standalone Rebates. (2018). Retrieved from http://www.energysmartyes.com/wp-content/uploads/2018/04/Stand-Alone-Eligible_Measures_for_ES-Q2CY18.pdf

[78] New York City - Property Tax Abatement for Photovoltaic (PV) Equipment Expenditures | Department of Energy. Retrieved from https://www.energy.gov/savings/new-york-city-property-tax-abatement-photovoltaic-pv-equipment-expenditures

[79] City of Chicago: Chicago Solar Express. Retrieved from https://www.cityofchicago.org/city/en/progs/env/solar_in_chicago.html

[80] Natural Gas Heating Equipment Rebates. Retrieved from https://www.masssave.com/en/saving/residential-rebates/gas-heating-equipment/

[81] Tune-Up Accelerator Program Details. Retrieved from http://www.seattle.gov/Documents/Departments/OSE/Accelerator/TUA_Detail_Overview.pdf

[82] Multifamily Performance Program: Existing Buildings. Retrieved from https://www.nyserda.ny.gov/All%20Programs/Programs/MPP%20Existing%20Buildingskh

[83] About Us | NYC Retrofit Accelerator. Retrieved from https://retrofitaccelerator.cityofnewyork.us/about-us

[84] Warmer Homes. Retrieved from https://www.london.gov.uk/what-we-do/housing-and-land/improving-quality/warmer-homes

[85] About the Retrofit Chicago Energy Challenge. Retrieved from http://www.retrofitchicago.net/about

[86] Living Building Pilot - Seattle. Retrieved from http://www.seattle.gov/dpd/permits/greenbuildingincentives/livingbuildingpilot/

Education & Training

Surveyed cities develop various forms of education and training programs to facilitate the market transformation. These programs can be classified into three categories based on their objectives: market awareness, regulatory compliance, and skill development.

Market Awareness

This type of training is designed to raise awareness of building energy efficiency in the general public. For example, the NYC Clean Heat Program organized four public webinar presentations to provide a basic introduction on the city's path to cleaner air. Topics covered in the presentations include the influence and need to eliminate heavy heating oil, relevant regulations and programs, available incentives and financing opportunities, and guide to next step.[87] To outreach to broad audiences, web-based presentations and text information are the most popular delivery approaches used for this introductory training type.

Regulatory Compliance

Cities design training programs to help both building owners and professionals (e.g., architects, engineers, and builders) familiarize relevant building energy regulations and compliance paths.

All surveyed cities offer traditional instructor-led training courses on energy conservation codes when there are any updates to the previous requirements. As these training courses were only held once or available during a certain period, cities also provided video, PDF and PowerPoint formats on official websites.

Additionally, all five cities with benchmarking policies established help centers to provide technical assistance by phone and email. Meanwhile, compliance checklist is used to improve data quality and compliance rates. To make the content more vivid, Boston and Chicago also design video tutorials. Besides online instructions, both NYC and Chicago offer group, hands-on training for building owners to comply with benchmarking ordinances. It is also noting that building owners in all five cities benefit from monthly Portfolio Manager training provided by the U.S. Environmental Protection Agency (EPA).

For building professionals, training on technical specifications helps them to understand specific requirements of an ordinance and ensure effective implementation. For instance, Boulder designs a 30-minutes online training program

[87] The Road to Cleaner Air This Heating Season. (2012). Retrieved from https://www.nyccleanheat.org/sites/default/files/public//4_Clean%20Heat%20Webinar%20The%20Road%20to%20Cleaner%20Air%20This%20Heating%20Season%2012_10_2012.pdf

for energy assessment and retro-commissioning service providers as the prerequisite for being included in the qualified contractor list.[88]

Skills Development

Surveyed cities also focus on knowledge capacity building of key stakeholders in the market. NYC, along with nonprofit partners, offers one- to two-day training courses for building owners, managers, and operations and maintenance (O&M) staff. These O&M training equip target trainees with knowledge about building energy systems, maintenance of equipment, and no- or low-cost energy saving measures.[89]

NYC and Chicago include knowledge enhancing measures in their voluntary leadership programs. The NYC Mayor's Office staff will meet representatives of participating buildings once a year to review progress and help them overcome obstacles. The city also convenes volunteer working groups of participants to encourage peer learning on an as-needed basis.[90] In addition to one-on-one consultations and networking events, Chicago develops the Energy Road Maps program to customize energy reduction strategies for Challenge participants.[91]

Summary of Lessons Learned

Key takeaways from the above analysis include the following:

- Clear and measurable target is the basis for developing energy efficiency policies and programs.
- Collaboration with local utilities and the private sector increases data completeness.
- Data reporting ensures information accessibility in the market, and data visualization and energy efficiency scorecards lead to better applications.
- Building benchmarking and transparency policy is a necessary component for regulations on the energy efficiency of existing buildings. Compliance checklist and help centers are designed to improve data quality and compliance rates.
- Compliance coverage, implementation timeline, and enforcement actions should be carefully considered for regulation design.
- Effective Incentives and education & training programs depend on an understanding of target audience and objectives of policies or programs.

---

[88] Boulder Building Performance - Service Providers. Retrieved from https://bouldercolorado.gov/sustainability/service-providers

[89] Ways to Save | NYC Retrofit Accelerator | Green O&M Training Hub. Retrieved from https://retrofitaccelerator.cityofnewyork.us/resources

[90] NYC Carbon Challenge for Commercial Owners and Tenants Program Design. Retrieved from http://www.nyc.gov/html/gbee/downloads/pdf/NYC_Carbon_Challenge_for_Commercial_Owners_and_Tenants_Program_Design.pdf

[91] Public-Private Partnership to Deliver Energy Road Maps | Better Buildings Initiative. Retrieved from https://betterbuildingsinitiative.energy.gov/implementation-models/public-private-partnership-deliver-energy-road-maps

- Influential organizations lead by example through voluntary leadership programs, paving the way for the broad-scale adoption of retrofitting projects.

Recommendations for Surrey

The lessons learned from the six leading cities have helped to define the following five recommendations that could be applied to the design of Surrey's policy ecosystem framework for existing buildings.

1. Maintain the city's commitment to the total GHG emissions reduction target and the annual retrofit rate of existing buildings, and use data, technical analysis, and stakeholder feedback to track and assess targets.
2. Improve compliance with existing building & construction regulations, implement a building energy benchmarking program, and launch a voluntary program for energy-saving actions such as energy audit, retro-commissioning, and lighting upgrade. The benchmarking program can target large buildings in the city first and gradually include mid-sized and small buildings.
3. Pilot incentive programs to provide technical and financial assistance for building owners to participate in existing and upcoming programs.
4. Build a public-private partnership to design and deliver education & training programs to raise market awareness, increase regulatory compliance, and develop knowledge and skills.
5. Develop a voluntary leadership program with incentives and education, engage influential organizations to lead the effort, and share best practices for late action takers to learn from the successes.

Future Research Recommendations

Based on the gaps identified in the above analysis, this section discusses the following three recommendations for further research.

1. Include funding and financing in the market transformation framework. Cities use funding programs to support the latest and innovative ideas and projects that may not readily be accepted by the public. For example, London funds ten selected homes to conduct net-zero energy retrofitting projects, showing the public how they will benefit from this cutting-edge technology and expecting the application of this technology will be in scale. On the other hands, financing programs help building owners to overcome high initial cost and foster deep energy retrofits. These two elements are noticeably missing in the current framework.

2. Conduct gap analysis with existing programs and policies that affect Surrey. The study can focus on two dimensions: programs that leading cities have but Surrey does not and good designs missing for current programs.

3. Understand the local context such as characteristics of existing building portfolios, energy prices, engagement of key stakeholders, and municipal powers to evaluate potential program success and identify barriers and restrictions in the market.

Appendix A: Mapping Energy Efficiency Policies and Programs for Existing Buildings

	Targets			Data & Reporting			Regulations			Incentives			Education & Training		
	Large Res	Small Res	Comm	Large Res	Small Res	Comm	Large Res	Small Res	Comm	Large Res	Small Res	Comm	Large Res	Small Res	Comm
New York City															
The NYC Carbon Challenge	■		■	■		■				■		■	■		■
2016 Energy Conservation Code							■	■	■				■	■	■
Greener, Greater Buildings Plan				■		■	■	■	■	■		■	■		■
Local Law 43: Heating Oil Regulations							■	■	■	■	■	■			
NYC Clean Heat				■	■	■				■	■	■	■	■	■
NYC Retrofit Accelerator										■		■	■	■	■
GreeNYC													■	■	■
New York City Energy Efficiency Corporation (NYCEEC)															
City of Boulder															
The SmartRegs	■	■					■	■		■	■				
Boulder Building Performance Ordinance						■			■			■			■
Energy Smart										■	■	■	■	■	■
2017 Energy Conservation Code							■	■	■				■	■	■
Comfort 365										■	■				
The Boulder Energy Challenge															
Boston															
The Building Energy Reporting and Disclosure Ordinance				■		■	■		■	■		■	■		■
Boston Community Energy Study				■	■	■									
Renew Boston Energy Efficiency Program											■			■	
Mayor's Carbon Cup	■		■	■		■				■		■			
Renew Boston Trust															

	Targets			Data & Reporting			Regulations			Incentives			Education & Training		
	Large Res	Small Res	Comm	Large Res	Small Res	Comm	Large Res	Small Res	Comm	Large Res	Small Res	Comm	Large Res	Small Res	Comm
Seattle															
Energy Benchmarking Program				■		■	■		■				■		■
The Building Tune-Ups Ordinance									■			■			
Existing Building Code							■	■	■						
The HomeWise Weatherization Program										■	■				
The Living Building Pilot Program										■	■	■			
Oil Furnace Replacement Program											■				
Sustainable Buildings and Sites Policy															
Chicago															
Chicago Energy Benchmarking Ordinance				■		■	■		■				■		■
The Retrofit Chicago Energy Challenge	■		■	■		■				■		■	■		■
Chicago Renewable Energy Challenge Program	■		■	■		■				■		■			
Retrofit Chicago Residential Partnership										■	■		■		
Chicago Solar Express										■	■				
Energy Conservation Requirements							■		■				■		■
The Chicago Infrastructure Trust															
London															
RE: NEW	■	■		■	■					■	■		■	■	
RE: FIT															
Business Energy Challenge						■						■			
Solar Together London										■	■	■			
Warmer Homes											■				
Energy Leap Project pilots															

Note: Large Res. and Small Res. are large and small residential buildings, respectively, and Comm. is commercial buildings. No specific square footage delineates small and large residential buildings; the categorization is based on how policies and programs are framed by the case study cities.