USING DATA FROM ACTION-ORIENTED ENERGY EFFICIENCY PROGRAMS AND POLICIES

Audit, Retrocommissioning, and Building Performance Standard Implementation Considerations for Policymakers

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PUTTING DATA TO WORK

REPORT

IMT
INSTITUTE FOR MARKET TRANSFORMATION

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ABOUT IMT

The Institute for Market Transformation (IMT) is a national nonprofit organization focused on increasing energy efficiency in buildings to save money, drive economic growth and job creation, reduce harmful pollution, and tackle climate change. IMT ignites greater investment in energy-efficient buildings through hands-on expert guidance, technical and market research, policy and program development and deployment, and promotion of best practices and knowledge exchange. For more information, visit imt.org

CONTENTS

PUTTING DATA TO WORK

The *Putting Data to Work* project began in 2015, with the aim of understanding how cities can use energy and building characteristic data generated through local policies to improve energy efficiency in buildings. Many cities have energy benchmarking and transparency policies requiring the largest buildings in their jurisdictions to report annual energy use to the city, which then makes those data public. *Putting Data to Work* was designed to help cities go beyond just publishing the energy data in their market to inciting action based on those data, building off of best practices developed through Washington, DC and New York City's many years of experience working with their policy data.

In February 2018, IMT published the *Putting Data to Work toolkit* of guides, case studies, sample scripts and reports to help cities and energy efficiency program implementers put the energy information available in their jurisdictions to use to move the market toward energy efficiency.

Following the publication of the toolkit, it became clear that additional resources would be useful to cities. Namely, guidance on collecting and using audit and asset information, and guidance on collecting and using newly-available monthly energy data through ENERGY STAR Portfolio Manager. This report is designed to fill the audit and asset guidance gap for cities, with monthly energy data being addressed in a separate report, Using Monthly Energy Data from Benchmarking Programs, published in parallel under this effort.

This guide includes considerations for jurisdictions trying to determine which level of audit to require and which data fields to collect from completed audit reports, and discusses asset data that can be collected from other processes that necessitate a site visit. We include best practice from jurisdictions that have been collecting audit data for several years, overviews of tools available for data collection and management, and recommendations for how cities can go beyond data collection to design programs and policies to advance energy efficiency.

EXECUTIVE SUMMARY

In the U.S., cities are driving climate action, implementing policies that regulate the built environment, and providing support and solutions to help decision makers in buildings save energy and reduce emissions. This report adds to the *Putting Data to Work toolkit*, which is designed to showcase how cities can use energy and building characteristic data collected through local policies to improve energy efficiency in buildings. The toolkit documents findings from a multi-year effort to help scale successes to additional cities across the U.S.

While the initial toolkit resources highlighted best practices for using energy information available publicly through local benchmarking and transparency policies, this guide focuses on asset information that is increasingly being collected by cities. This guide is meant to help local government decision makers design action-oriented policies (such as retrocommissioning or retuning policies, or building performance standard policies) and collect and manage asset information made available through associated audits.

This guide contains three sections:

- **Section 1: Background** provides an overview of action-oriented building policies and the types of information that can be generated through these policies.
- **Section 2: Cities with Action-Oriented Policies** summarizes the existing action-oriented policies in the U.S., including a case study of how New York City's suite of policies and programs are founded on the information being made available through policy.
- **Section 3: Methods for Collecting Asset Data** analyzes the types of information available through each type of audit, and provides considerations and recommendations for cities designing policies that include asset data collection.

The specific actions and analysis that are enabled by collecting and using asset information are discussed throughout the report, but at the highest level, the benefits of specific data to cities include:

- **An Equipment and Systems Inventory** allows cities to identify prevalent systems in the building stock that represent ripe opportunities for energy savings, including the approximate end-of-use for systems in specific buildings. This also helps track the proliferation of energy-saving equipment and technologies in the building stock.
- **Recommended Energy Conservation Measures** shows cities what local energy auditors or retuning agents consider to be the most reasonable opportunities for saving energy in the city's buildings, provides an opportunity to estimate the expected cost of improving high-impact systems across a city, and offers the opportunity to provide guidance to auditors on energy conservation measures to highlight.
- **A Breakdown of Energy Consumption by End Use** provides insight into how energy use breaks down by end-use system.

In order to meet ambitious and necessary climate goals, cities need to require action by building owners to reduce energy waste. These requirements should be designed to provide a feedback loop of information that allows cities to continue designing programs and policies that best support the needs of their building owners and tenants in continuing to improve energy efficiency, and should focus on the highest impact actions for energy savings.

Recommendations

High-level recommendations based on observations presented in this report are captured below.

Phase	Recommendation	Additional Details in Report
Policy Design	Require building owners to take action to improve energy efficiency.	Section 1: Background
	Build off of lessons learned in jurisdictions that have passed similar policies and implemented similar programs.	Section 2.1: Cities Requiring Action
	Create programs and policies catered to the local jurisdiction's priorities and needs.	Section 2.1: Cities Requiring Action
	Consider the balance between requiring audit and retuning.	Section 2.2: Managing Data
Data Management and Collection	Integrate all agencies that deal with buildings, create centralized database for building-related information.	Section 2.3: Case Study: New York City
	Standardize data collection.	Section 2.2: Managing Data
	Collect ECM and systems information, regardless of the policy requirements.	Section 2.3: Case Study: New York City
	Investigate available tools for data collection, management and analysis.	Section 2.1: Cities Requiring Action
Data Analysis and Application	Identify the most common system types and ECMs in the local jurisdiction.	Section 3: Methods for Collecting Asset Data – Equipment and Systems Inventory
	Design technical assistance and incentive programs around the highest-potential energy-saving ECMs based on the information being collected.	Section 3: Methods for Collecting Asset Data – Equipment and Systems Inventory

SECTION 1 Background

Cities are on the front lines of climate change. They deal with the logistics of cleaning up flooded homes and businesses from ever-more powerful storms, rebuilding leveled communities from increasingly powerful and frequent wildfires, and finding reliable water sources for their constituents during prolonged droughts. Consensus in climate science research is that these problems will continue to worsen as our global climate continues to warm.

Grappling with these impacts on their communities first hand, cities are also leading the charge to mitigate the causes. Recognizing the connection between emissions levels and climate change, many cities are setting ambitious greenhouse gas (GHG) reduction and renewable energy power targets, and they are exercising the authority of local leadership to implement real, impactful solutions.

In most urban areas, the energy produced for and used in buildings is the greatest source of GHG emissions, accounting for 50–80 percent of a city's total emissions. This makes programs targeting energy efficiency in buildings a high priority for city governments. The first, and cheapest, source of energy is the energy that is not used, so it is important to target energy efficiency even as cities increase the amount of clean, renewable energy powering their jurisdictions.[1] Additionally, as the levels of intermittent renewable energy increase, the costs of using this electricity will rise due to the need for new grid investments to maintain reliable power and to deliver power from afar. Energy efficiency minimizes the need for excess renewables and costly grid upgrades, and therefore remains central to achieving clean energy and climate goals in an economic and timely fashion.

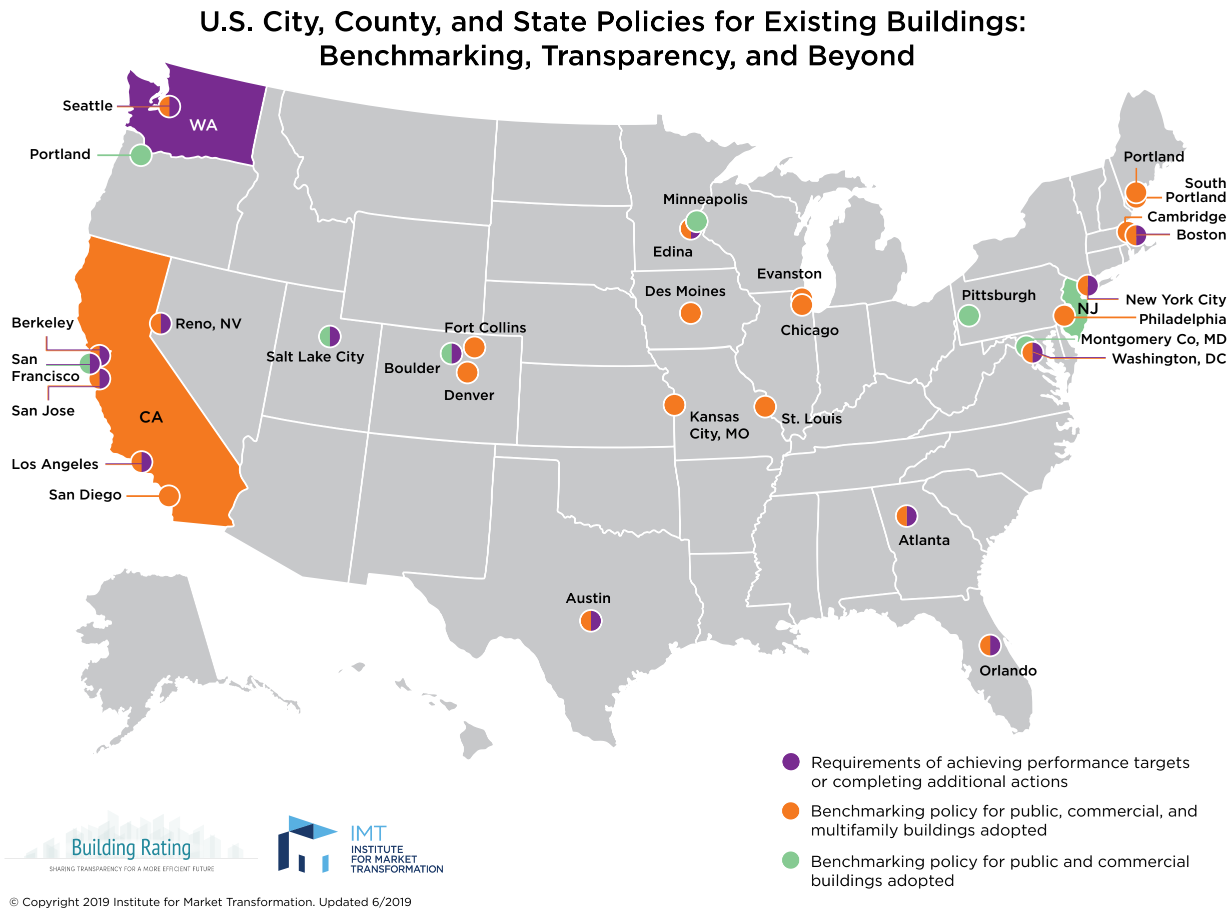
1.1 Overview of Building Performance Policies

There are several types of local building energy performance policies that require varying degrees of information to be reported to the regulating jurisdiction about existing buildings, and varying degrees of action to be taken on the part of the building owner. These are summarized below and in Figure 1.

- **Benchmarking and Transparency**: Benchmarking and transparency policies require owners of buildings over a certain size threshold (typically 10,000–50,000 square feet, depending on the jurisdiction) to report their annual energy performance to the city. The city then makes that information public for use in the market through spreadsheets, visualization maps, and other means of communication. To date, more than 30 jurisdictions in the U.S. have mandatory benchmarking and transparency policies in place. For more information on how cities are using this information, reference *Putting Data to Work: How Cities are Using Building Energy Data to Drive Efficiency.*

- **Retuning**: A number of jurisdictions require building tune-ups, or retuning, which require owners of large buildings to hire a qualified professional to document and correct operational inefficiencies. Retuning requirements focus almost exclusively on identifying opportunities to improve a building's operations and maintenance to achieve energy savings. In addition to focusing on operational inefficiencies, retuning also involves making low- and no- cost repairs and adjustments that often result in immediate energy savings.
- **Audits and Retrocommissioning:** These requirements are often framed primarily as a way to inform building owners of opportunities to improve their buildings (audits) or to have qualified professionals make low- or no-cost improvements to buildings' operations, yielding immediate energy savings (retrocommissioning). Additional information about these policies is available in *Section 2: Cities Requiring Action*.
- **Building Performance Standards:** Several leading jurisdictions, including Washington, DC and New York City, have passed building performance standards, which require buildings to achieve a minimum threshold of performance, based on energy use (in the case of the District) or emissions generated (in the case of NYC). These policies require action to be taken to improve energy efficiency for buildings not meeting the performance threshold, and the enforcement of these policies relies on data reported under these cities' benchmarking and transparency policies.

Figure 1: **Mandatory Building Energy Performance Policies for Existing Buildings in the U.S.**[2]



1.2 Audits and Asset Data

1.2.1 Definition of Asset Data

Asset data includes information about the building as a physical asset, regardless of occupancy or occupant behavior. This includes information about a building's construction, equipment and systems, and its energy use, as well as potential opportunities for improvement. These data are useful for local governments that are planning campaigns, programs, or policies to reduce building energy consumption. For cities, the most common way to collect asset data is by requiring building owners to report it as part of an ASHRAE Level 1 audit, ASHRAE Level 2 audit, or a retuning process. Refer to Table 1 in the next subsection for additional detail on these processes.

To date, 12 jurisdictions have requirements that involve collection of asset data through mandated energy audits and/or retuning or retrocommissioning. The asset data generated during these required processes has significant analytical value for local governments and other parties interested in improving the efficiency of existing buildings, as discussed in *Section 2* of this report.

1.2.2 Overview of Types of Audits

An energy audit broadly refers to an assessment of the energy-consuming systems and energy efficiency needs of a building. The types of audits differ, and Table 1 summarizes the most commonly referred to audits in building energy policymaking, with ASHRAE Level 1 and 2 being the most common in current policies.

Table 1: **Types of Audits**

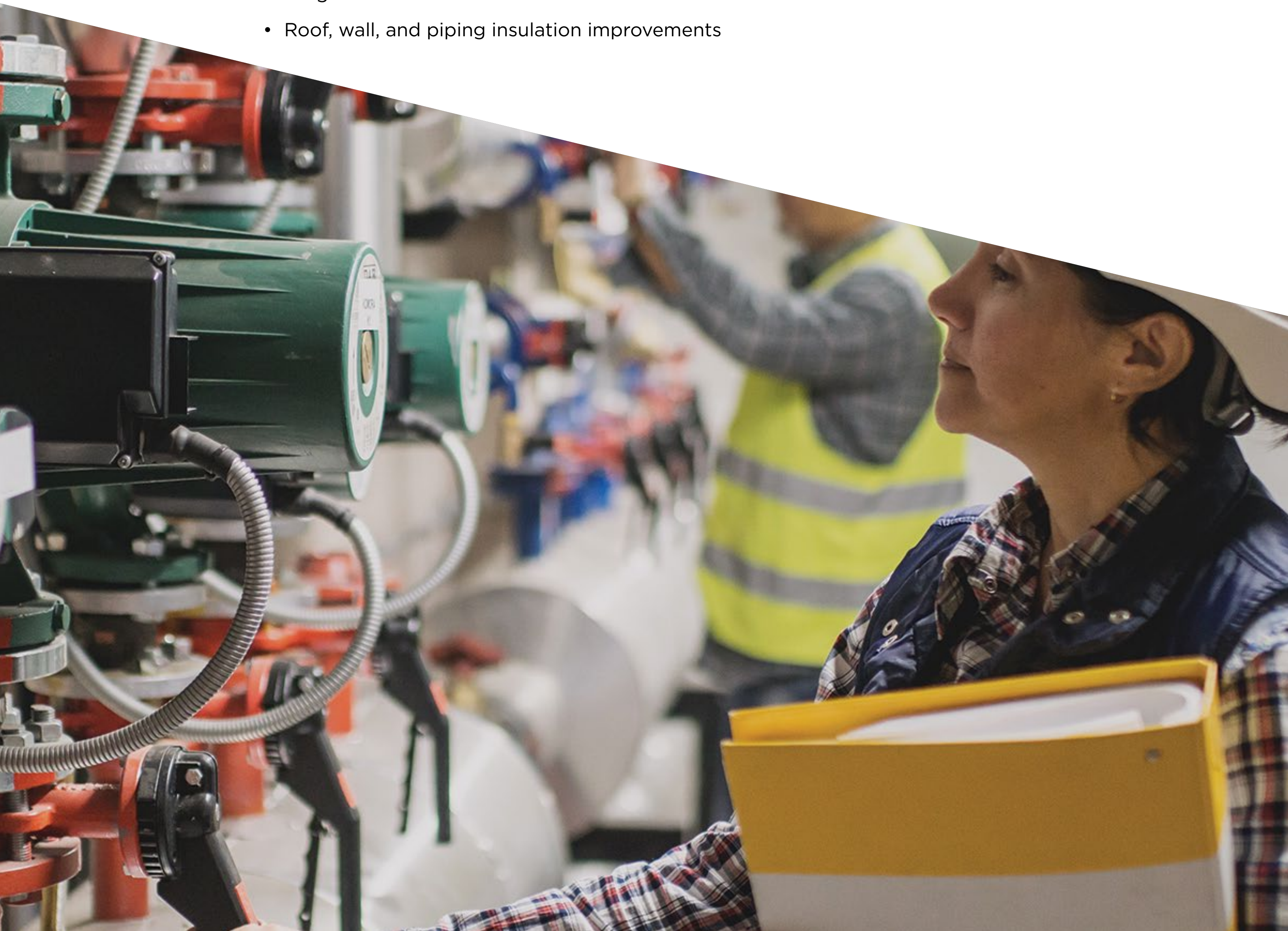
		ASHRAE Level 1 "Walk Through"	ASHRAE Level 2	ASHRAE Level 3 "Investment Grade"
Cost[3]		Approximately $0.12 per square foot, varies based on size and complexity.	Approximately $0.20 per square foot, varies based on size and complexity.	Approximately $0.50 per square foot, varies based on size and complexity.
Description		Preliminary walk-through analysis that identifies low-cost, easily visible, energy conservation measures. It typically uncovers major problem areas in energy flow.	Includes ASHRAE Level 1, with more detailed data collection, analysis, and end-use breakdown of energy flows.	Includes ASHRAE 1 and 2, with comprehensive analysis of energy flows in the building, often done as part of an Energy Savings Performance Contract (ESPC). Focus on return on investment for recommended ECMs.
Data Collected	Equipment and systems inventory	☑	☑	☑
	Auditor's recommended ECMs	☑	☑	☑
	End-Use Breakdown describing how energy is apportioned to general end uses such as heating, cooling, domestic hot water		☑	☑
	Energy monitoring and data collection			☑
	Engineering analysis			☑

The specific action required in these policies varies. Some jurisdictions require energy and/or water audits, some require the low- and no-cost findings of those audits to be implemented, and some require retrocommissioning and retuning. The specifics of the policies in each of these jurisdictions are outlined in Table 2 of this report.

1.2.3 Common ECMs Identified through Audit and Retrocommissioning Policies

The implementation of a building performance policy is only successful if it drives decision makers to take action to improve the energy efficiency of their buildings. To that end, many "beyond benchmarking," or action-oriented policies require building owners to implement energy conservation measures (ECMs). Common ECMs identified through audits include:

- HVAC controls installation and optimization
- HVAC equipment upgrades
- HVAC ventilation and distribution system improvements
- Lighting upgrades (e.g. replacing existing lighting bulbs or fixtures with higher efficiency bulbs or fixtures, installing occupancy sensors and controls, installing task lighting in lieu of ambient lighting)
- Programmable thermostats
- Roof, wall, and piping insulation improvements



The Community Preservation Corporation (CPC) is a nonprofit organization that focuses on supporting affordable housing and community revitalization. The CPC provides an efficiency measure checklist in its Underwriting Efficiency guide, which is shown in Figure 2. While focused primarily on multifamily housing, the guide provides a representative overview of common measures in many building types. The measures are divided into simple upgrades (such as installing sensors, upgrading lighting, insulating piping), moderate renovation (replacing larger fixtures, submetering and installing roof insulation), and substantial improvements (such as replacing the building envelope, installing solar, and replacing large building systems).

Note that the CPC guide provides estimated savings potential (in percentage) for each ECM, which is useful for policymakers in deciding which combination of ECMs might meet a threshold (for example, 20% total savings) to be included in a prescriptive package for compliance. For building owners and service providers, the payback period of ECMs is also a key metric in considering which measures to undertake. The U.S. Department of Energy's (DOE) Better Buildings Solutions Center houses "showcase projects," or case studies that include information on cost and return for projects by specific building types, sectors, and technologies.[4]

In addition to requiring that some action be taken, either through a prescriptive checklist or through requiring low- and no-cost ECMs be implemented, a city considering passing an audit policy should collect systems information in order to identify common system types to inform program design. For example, in NYC, the city used data collected under its audit policy to design the Retrofit Accelerator's programs around common system types in the city (steam heating systems), which is discussed further in *Section 2: Cities Requiring Action*. Common systems and opportunities for energy improvement may vary by jurisdiction because of climate, common local building practices, or other factors, so this locally specific, building systems information helps inform the most applicable program design.

Building on the knowledge of common systems and opportunities for energy improvement, the city can then use asset information to come up with a recommended or prescriptive list of actions based on the ECMs that result in the highest energy savings potential for system types in its jurisdiction. This may be useful for a compliance pathway for a building performance standard, or as a guidance for utility or efficiency program offerings within the city.

Figure 2: **CPC's Efficiency Measure Checklist**[5]

Category		Measure	Property Type	Non-Energy Benefits	Savings
SIMPLE UPGRADE	☐	Install Programmable Thermostats	Any		3%
	☐	Install Low-Flow Sink Aerators	Any		3%
	☐	Install Low-Flow Showerheads	Any		4%
	☐	Air-Seal Common Areas	Any		2%
	☐	Upgrade Common Area Lighting	Any		4%
	☐	Upgrade Apartment Lighting	Any		2%
	☐	Install Exhaust Fan Timers	Any		1%
	☐	Repair Heating System Leaks	Central Boiler Heat		2%
	☐	Insulate Heating Pipes	Central Boiler Heat		1%
	☐	Tune Up Heating System	Central Boiler Heat		2%
	☐	Insulate DHW Pipes and Tank	Central DHW		1%
	☐	Install DHW Controls	Central DHW		2%
	☐	Insulate Condensate Tank	Steam Heat		1%
	☐	Install or Upgrade Master Venting	Steam Heat		3%
	☐	Replace or Repair Steam Traps	Steam Heat		3%
MODERATE RENOVATION	☐	Replace/Upgrade Packaged HVAC	Any		5%
	☐	Increase Roof Insulation	Any		3%
	☐	Upgrade Motors or Install VFDs	Any		4%
	☐	Replace Washing Machines & Dryers	Any		1%
	☐	Upgrade Exhaust Fans	Any		2%
	☐	Replace Toilets	Any		10%
	☐	Replace Windows and Glazing	Any		4%
	☐	Replace Refrigerators	Any		2%
	☐	Replace Exterior Doors	Any		1%
	☐	Install Heating System Sensors	Central Heat		1%
	☐	Install Central Heating Controls	Central Heat		6%
	☐	Upgrade or Repair Burner	Central Boiler Heat		3%
	☐	Upgrade DHW Boiler	Central DHW		3%
	☐	Install Thermostatic Radiator/ Valves or Zones	Central Boiler Heat		5%
	☐	Convert Heating System from Oil to Gas	Oil-Fired Heating		10%
	☐	Install Submetering	Master-Metered		15%
	☐	Install Irrigation Controls	Landscaped, Garden-Style		13%
SUBSTANTIAL IMPROVEMENTS	☐	Increase Insulation - Wall	Any		4%
	☐	Overhaul Building Envelope	Any		20%
	☐	Convert to Electric Heat Pumps	Any		30%
	☐	Install Solar/Photovoltaic	Any		20%
	☐	Repair Extensive Domestic Water Leaks	Any		N/A
	☐	Replace Boiler	Central Heating Boiler		10%
	☐	Install Combined Heat and Power	Central DHW		20%
	☐	Separate DHW from Heating	Central Heating Boiler & DHW		5%
	☐	Overhaul Ventilation System	Central Ventilation		3%
	☐	Install Energy Recovery Ventilation	Central Ventilation		4%

Recommendations for Local Governments

Collect and use systems information.

For most beyond benchmarking policies that require action (including retuning), a building audit of some level will need to be conducted in order to identify ECMs and develop an implementation plan. Cities should take advantage of, at minimum, the high-level building systems information that auditors will gather as part of this process by requiring that building owners submit this information to the city as part of its policy design. As discussed further in *Section 3: Methods for Collecting Asset Data*, this information can be valuable in designing programs best targeted toward the most impactful systems in a jurisdiction, as well as in conducting outreach, focusing investment, advocating to PUCs and utilities, and in helping guide building owners more directly toward more holistic energy retrofit projects.

Require action to improve energy performance.

While benchmarking and transparency policies are foundational to provide information about building energy performance to the market, it is essential that building owners be required to take action in order to continuously improve the energy performance of the full building stock. The specific combination of actions will vary based on local goals and political momentum, but should be geared toward ongoing improvement of the building stock. Cities should prioritize actions that both produce valuable information (for example, an audit) and actions that require improvement of energy performance and realize savings (for example, retrocommissioning).

SECTION 2
Cities Requiring Action

2.1 Cities Requiring Audits or Retrocommissioning

The 12 jurisdictions that currently have an action-based building energy policies that include audits, retuning, or retrocommissioning, are summarized in Table 2. These jurisdictions vary in the specific requirements, the data collected to verify compliance, and the ways that they use the information being collected through these policies. The following subsections discuss ways that cities are currently managing and using audit data, while *Section 3: Methods for Collecting Asset Data* covers the specific value of three key types of information collected through most audits, as well as additional considerations and recommendations.

Table 2: **Energy Audit and Retrocommissioning Policies**

Jurisdiction	Law	Covered Buildings	Action and Frequency
Atlanta	Commercial Energy Efficiency Ordinance	Commercial 25,000 sq. ft. or larger	Energy audit every 10 years
Berkeley	Building Energy Saving Ordinance	Commercial and multifamily 25,000 sq. ft. or larger	Energy audit prior to sale
Boston	Building Energy Reporting and Disclosure Ordinance	Commercial and multifamily 35,000 sq. ft. or larger (buildings 50,000 sq. ft. or larger have more stringent requirements)	Audit or energy action (significant investment in efficiency, comprehensive energy management plan, retrocommissioning of energy systems) every 5 years
Boulder	Building Performance Ordinance	Commercial 20,000 sq. ft. or larger (10,000 sq. ft. or larger for buildings built after 2014)	Energy audit and retrocommissioning (RCx) every 10 years, owner must implement any RCx measure with payback of 2 years or less
Los Angeles	Existing Buildings Energy and Water Efficiency Program	Commercial and Multifamily 20,000 sq. ft. or larger	Energy audit and retrocommissioning every 5 years
New York City	Local Law 87	Commercial and multifamily 50,000 sq. ft. or larger	Energy audit and retrocommissioning every 10 years
Orlando	Ordinance No. 2016-64	Commercial and multifamily 50,000 sq. ft. or larger	Energy audit or retrocommissioning every 5 years for buildings with ENERGY STAR score lower than 50
Reno	Energy and Water Efficiency Program	Commercial and municipal properties 30,000 sq. ft. or larger, municipal properties 10,000 sq. ft. or larger	Buildings not meeting performance target every 7 years must do an audit or retuning
Salt Lake City	Commercial Building Benchmarking and Market Transparency Ordinance	Commercial 25,000 sq. ft. or larger	Tune-ups every 5 years
San Francisco	Existing Commercial Buildings Energy Performance Ordinance	Commercial 10,000 sq. ft. or larger (buildings 50,000 sq. ft. or larger have more stringent requirements)	Energy audit every 5 years
San Jose	Energy and Water Building Performance Ordinance	Commercial and multifamily 20,000 sq. ft. or larger	Buildings not meeting performance target every 5 years must do an audit, retrocommissioning, or undertake energy efficiency improvement measures
Seattle	Building Tune-Ups Ordinance	Commercial 50,000 sq. ft. or larger	Building tune-up every 5 years

At the time of publication of this report, three jurisdictions in the U.S. had passed building performance standards (BPS), as outlined in Table 3. BPS are policies that set a minimum required level of performance for covered existing buildings, often in a manner similar to building energy code requirements for new construction and renovations. To date, there are two main types of BPS: one uses energy as the performance metric, and the other uses carbon as the performance metric. For each type of BPS, owners of buildings performing below the standard are required to improve their building performance to meet or surpass it by a prescribed date or make tangible investments to improve their performance. The standard is enforced by fines or other compelling penalties.

Table 3: **Comprehensive Existing Building Performance Standards in the U.S.**

Jurisdiction	Minimum Performance Threshold	Covered Buildings	Improvement Requirements	Prescriptive Requirements
New York City Local Law 97	Building **CO_2e emissions limits** are applied on a square-foot basis by building type	Commercial and multifamily buildings 25,000 sq. ft. or larger, or two buildings on the same tax lot collectively exceeding 50,000 sq. ft.	The law specifies CO_2e limits for each building type for the first two compliance periods. They can be met through any combination of efficiency improvements, onsite distributed energy resources, purchase of (expensive) renewable energy certificates (from zone J) or greenhouse gas offsets (up to 10% of emissions limit)	Affordable housing, buildings with rent-regulated residential units and houses of worship must only carry out lower-cost prescribed energy-saving measures, such as insulating pipes and installing thermostats to control radiators.
State of Washington House Bill 1257	TBD, but based on **site energy use intensity (EUI)**, and must be no greater than the average EUI for the covered building occupancy type under ANSI/ASHRAE/IES Standard 100-2018	Commercial buildings 50,000 sq. ft. and larger	TBD, but based on Standard 100 and must ensure that buildings not meeting threshold are taking action to achieve reductions, and must ensure building owner adopt an implementation plan (based on investment-grade audit)	TBD, must be an optimized bundle of energy efficiency measures that provides maximum energy savings without resulting in a savings-to-investment ratio of less than 1.0
Washington, DC CleanEnergy DC Omnibus Amendment Act of 2018	TBD, but at least the median **ENERGY STAR** score (or equivalent for buildings that cannot receive an ENERGY STAR score) of the peer building group	Commercial and multifamily 10,000 sq. ft. or larger	TBD, at least 20% decrease in site EUI over previous 2 years' average (every 5 years)	TBD, must be cost-effective measure with savings comparable to 20% savings from performance pathway (every 5 years)

2.2 Managing Data

Collecting asset information is only useful for planning and policymaking if that information is accurate, well organized, and accessible by the parties that need it. Several factors come into play when planning out an asset-related, action-oriented policy, including:

- **Staff capacity and expertise**. Successfully implementing an action-oriented policy requires setting up data management systems, supporting compliance, evaluating the accuracy and completeness of the data, and analyzing the information. These are labor-intensive activities, especially in the first few years of implementation, so a city should gauge whether it has the in-house capacity and expertise, or whether it may need to contract with a third party or work with a nongovernmental organization (NGO) or utility to partner on some or all of these functions.
- **Quality of audits**. Data should be verified for completeness and accuracy. This can be done by requiring that auditors have certain certifications (such as Certified Energy Manager (CEM), Professional Engineer (PE) or others), or by conducting post-submission cleansing and analysis. For example, San Francisco collects less detailed information than NYC, and has focused in early compliance cycles on collecting all recommended ECMs and checking for completeness and accuracy. While not a requirement, almost all of the audits reported to the city have been conducted by a PE.[6]
- **Standardization of systems**. Multiple city departments interact with buildings, including buildings departments (permitting, code enforcement, energy benchmarking), tax departments, public works, the mayor's office, emergency response, economic development, and others. Wherever possible, systems and data platforms should be integrated to allow departments to access all applicable information about a building within a jurisdiction, rather than maintaining parallel (and often duplicative) systems. An example of this streamlining is in San Francisco, where the city is consolidating individual customer relationship management (CRM) platforms from multiple programs, migrating its Salesforce platform to a single CRM account to streamline information on buildings.
- **Applicability of information being collected**. There is a labor cost in collecting and managing data, and jurisdictions should balance this with the usefulness of the information being collected. At minimum, this should include base buildings systems information and ECMs, but may include more granular detail if the city has the in-house or support capacity to use the information. For example, New York City collects a significant amount of data through its Local Law 87 audit policy, but the large amount of information collected is justified, as it uses that information for developing city plans (such as the Buildings Technical Working Group),[7] policies (such as Local Law 97 of 2019),[8] and programs (such as the Retrofit Accelerator)[9] to help building owners advance energy efficiency. Reference *Appendix A: Comparison of NYC and Seattle Equipment Inventory Workbooks* for additional detail on NYC's equipment inventory data collection.

Cities that currently collect audit data use a combination of excel spreadsheets and the U.S. Department of Energy-provided (DOE) Audit Template tool. Audit Template was developed by DOE and Pacific Northwest National Laboratory (PNNL) to collect energy audit data and ECMs. The platform allows cities to collect applicable fields, download via CSV, or connect to other DOE data tools through BuildingSync. Audit Template is web-based, and follows the ASHRAE Standard 211 "Standard for Commercial Building Energy Audits," though it can be customized to suit different local jurisdictions' audit requirements.[10] Most cities, including Atlanta, Los Angeles, New York City, and San Francisco, have collected their first few years of data through spreadsheets and are migrating to the use of Audit Template in order to standardize and streamline processes.

2.3 Case Study: New York City

A key benefit of a city receiving and acting upon the asset data of its building stock is that the city can better understand the energy profile of its built environment, and understand contributing factors to that profile. Prior to this information being available, cities did not have this ability.

Of all the U.S. jurisdictions currently collecting asset data from buildings, New York City has done the most to analyze that information and apply findings. Under Local Law 87 (LL87), part of the Greener Greater Buildings Plan, New York requires that buildings over 50,000 square feet undertake audits and retrocommissioning every 10 years, and submit the findings of the effort through and Energy Efficiency Report (EER) to the city.[11] New York City collects three main types of data about audited buildings through its EERs, consistent with an ASHRAE Level 2 audit:

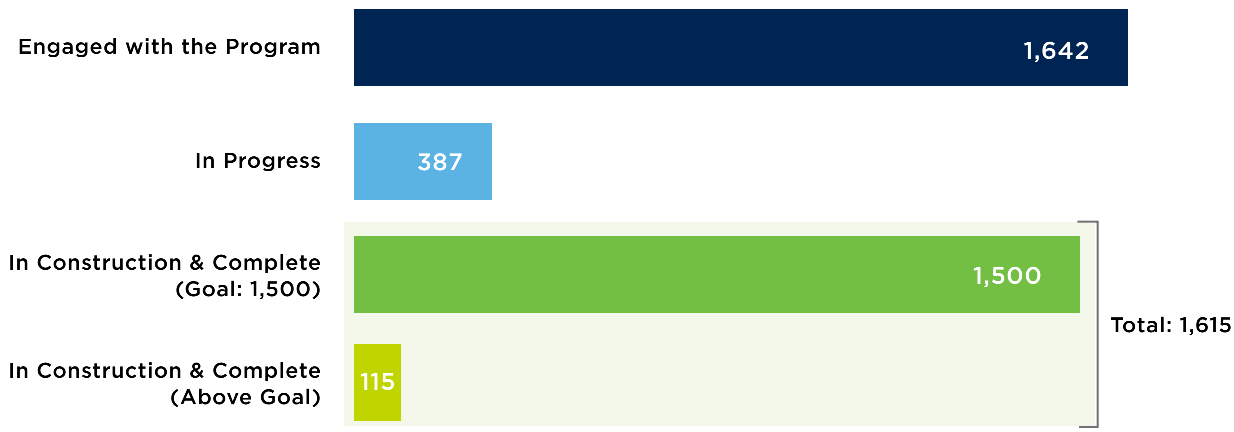
- Analysis of Energy Consumption by End Use (End-Use Breakdown)
- Equipment and Systems Inventory
- Recommended Energy Conservation Measures

New York City's One City: Built to Last, released in September 2014, commits the city to designing programs and policies that encourage privately owned building decision makers to use their energy audits and benchmarking information to take steps to reduce their buildings' energy consumption, in addition to many other initiatives to reduce buildings-based GHG emissions.[12] The NYC Retrofit Accelerator is one of the key programs that launched under the One City plan. This program provides privately owned building decision makers with free technical assistance and guidance for undertaking energy and water efficiency upgrades. The Retrofit Accelerator utilizes the data collected from local benchmarking and audit ordinances in two primary ways: first, to identify buildings with the highest opportunities with regard to energy consumption and system types, and second, to assist building decision makers with using the information in those reports to increase the value and sustainability of their buildings.

The collection of both the benchmarking and energy audit data is crucial to the implementation of the data-driven outreach strategy utilized by the Retrofit Accelerator. The analysis used to derive strategy for the Accelerator ranked properties by four main indicators: high savings potential, high need, high project opportunity, and low-hanging fruit. The high savings potential indicator acted as a filter for all the other indicators, and was generated by creating data flags primarily from benchmarking data and Department of Environmental Protection boiler data to indicate high energy usage compared to peers. These data flags were then rolled up, allowing the program to rank buildings that have the highest savings potential based on the number and type of flags that were triggered. All buildings with associated benchmarking reports were ranked according to this methodology. The systems inventories and ECM recommendation information collected through LL87 EERs were then layered on to help identify specific project opportunities. Buildings that had systems with ECM recommendations that would take longer lead times to implement and result in high energy savings, such as boiler replacements, were flagged as high-opportunity projects. These two indicators were then combined to identify the highest priority buildings for outreach. In addition to identifying high-priority buildings, this analysis allows the Retrofit Accelerator staff to assist portfolio managers identify specific opportunities for their portfolios.

For additional detail on this process, refer to the case study *Putting Data to Work: Successful Partnerships to Accelerate Efficiency*. As of the summer of 2019, the Retrofit Accelerator had exceeded its goal of serving 1,500 properties, as shown in Figure 3.[13]

Figure 3: **Retrofit Accelerator Properties Served as of Summer 2019**



In addition to assisting those building decision makers that have undertaken their energy audits, this process has allowed the city to identify common system types and ECMs, and design targeted campaigns around high-potential energy conservation projects, including the campaigns outlined below.

- The Better Steam Heat[14] campaign targets one of the most prominent heating system types in New York City with simple, packaged upgrades that include tuning the boiler, venting pipes, installing controls, insulating pipes, and repairing steam traps. The campaign is designed to help building owners address the system as a whole, maximizing potential savings. Key components include:
  - The city serves as a third-party technical advisor through the entire life of the project
  - The city provides training to contractors and maintains a list of service providers who have been through the training[15]
  - The city provides assistance finding incentives to pay for the upfront cost of the work

- Designed to build off of the Better Steam Heat campaign by providing envelope upgrades to ensure added efficiency, the Stop the Drafts air sealing and building envelope campaign addresses the roof, walls, windows, doors, and foundation of a building.[16] Similar to the Better Steam Heat campaign, the city serves as a technical advisor through the life of the projects, helps to package upgrades into projects that make sense for a building, and provides assistance identifying incentives.

- The city also established a leading-edge High Performance Retrofit Track, consisting of about 25 buildings whose owners were willing to go beyond single-measure or packaged retrofits to incorporate energy efficiency into long-term (10–15 year) capital planning and reduce energy use by 40 to 60 percent. These buildings—representing office, multifamily residential, healthcare, universities, and mixed-use—then serve as examples for what is possible in the NYC market. Profiles and case studies are available through the Building Energy Exchange, the city's partner in educating and connecting the real estate and design communities on the benefits of high-performing buildings.[17]

In addition to the work being done through the Retrofit Accelerator, in August 2016, the city of New York, Urban Green Council, and the New York University Center for Urban Science and Progress published the first reports examining asset data collected from office and multifamily buildings through the city's ASHRAE Level 2 energy audit requirement for buildings larger than 50,000 square feet.[18] Those reports generated a number of significant findings that were enabled by the asset data collected through audits. These include:

- Multifamily and office buildings make up almost 90 percent of energy use in buildings that benchmark in the city. This tells the city to focus on these building types.
- Building energy efficiency is improving over time, by eight percent since the beginning of implementation of LL84 and LL87. This suggests that the city's programs are leading to savings, but need to be scaled up to meet the ambitious 80 percent reduction by 2050 goals.
- Common conservation measures recommended include refurbishing steam heating, sealing building envelopes, and upgrading lighting. This tells the city which program packages will be the most applicable for the Retrofit Accelerator.

Recommendations for Local Governments

Standardize data collection

The data fields collected should be balanced against the jurisdiction's capacity to appropriately manage the data and make the information useful. At minimum, these should include systems information and compliance information for successful implementation of the policy, but may be more granular if the jurisdiction is able to process and analyze deeper data. In addition, the jurisdiction should standardize the process by which data are collected and managed to ease implementation year over year, and should use DOE's Audit Template to collect and manage the asset data.

Engage all city departments that work in buildings

Multiple city departments interact with buildings, and a centralized database of information related to buildings could be of benefit for both the efficiency of administration on the city's part, and for the customer experience on the building owner's part. All departments that could potentially interact with buildings, and be expected to integrate into the centralized system, should be involved in the process of selecting and designing the platform. The successes seen in NYC and Seattle are partially attributable to this cross-agency coordination.

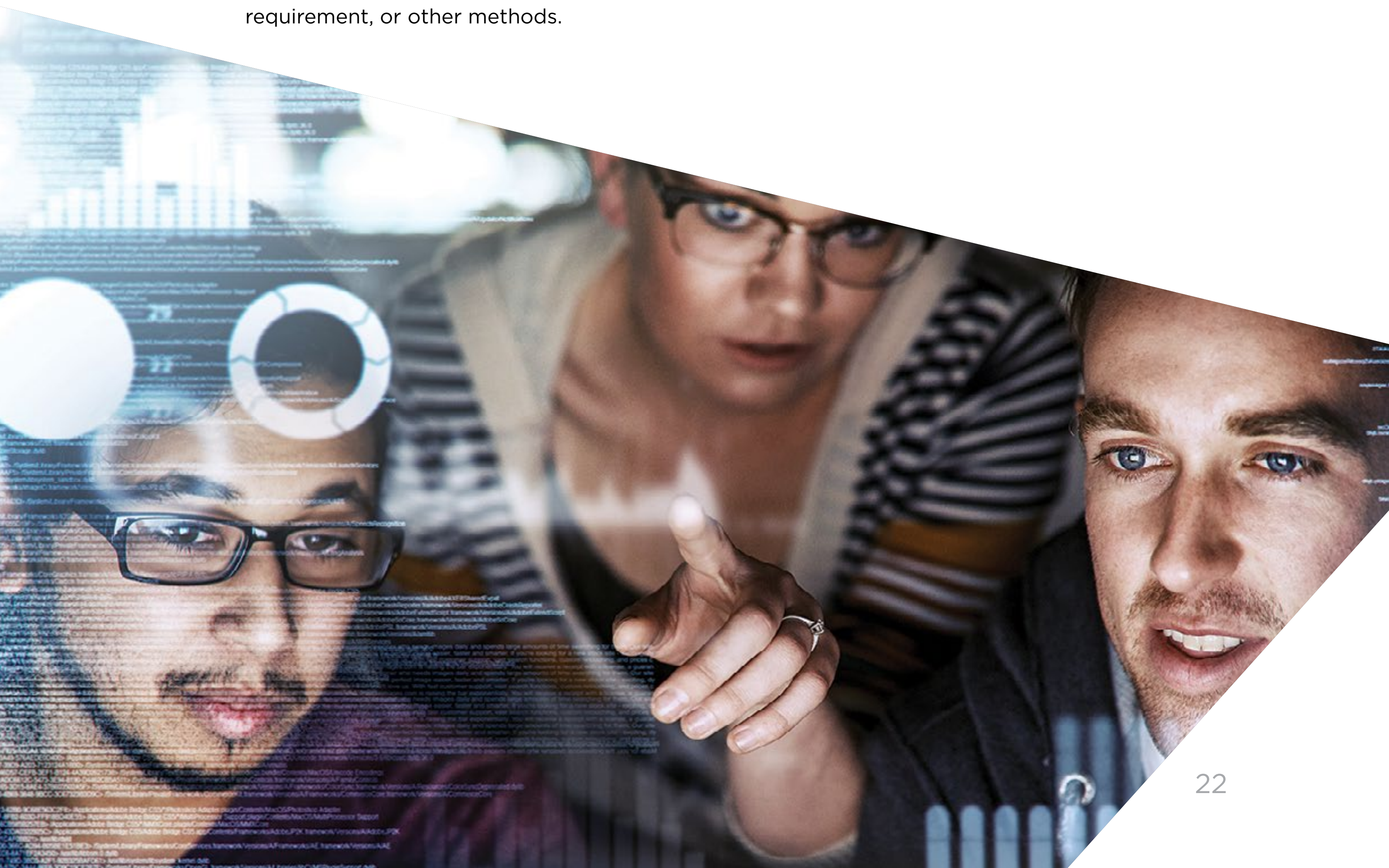
Identify the most impactful system types and ECMs in the local jurisdiction

By collecting ECM and system information from an audit or retrocommissioning policy, a jurisdiction can identify the most common systems and conservation measures, and design programs and policies (or partner to offer programs) catered toward those that are most applicable in the local area.

SECTION 3
Methods for Collecting Asset Data

As discussed above, it is common for local governments to explore adopting "beyond benchmarking" or action-oriented requirements, which often take the form of energy audits or retuning mandates, both in conjunction with a benchmarking and transparency ordinance or in addition to an existing one. These governments often have questions about the pros and cons of audits and retuning requirements, both in terms of their efficacy as tools to motivate building owners to invest in energy-saving measures and in terms of the value and usefulness of the asset data they can provide.

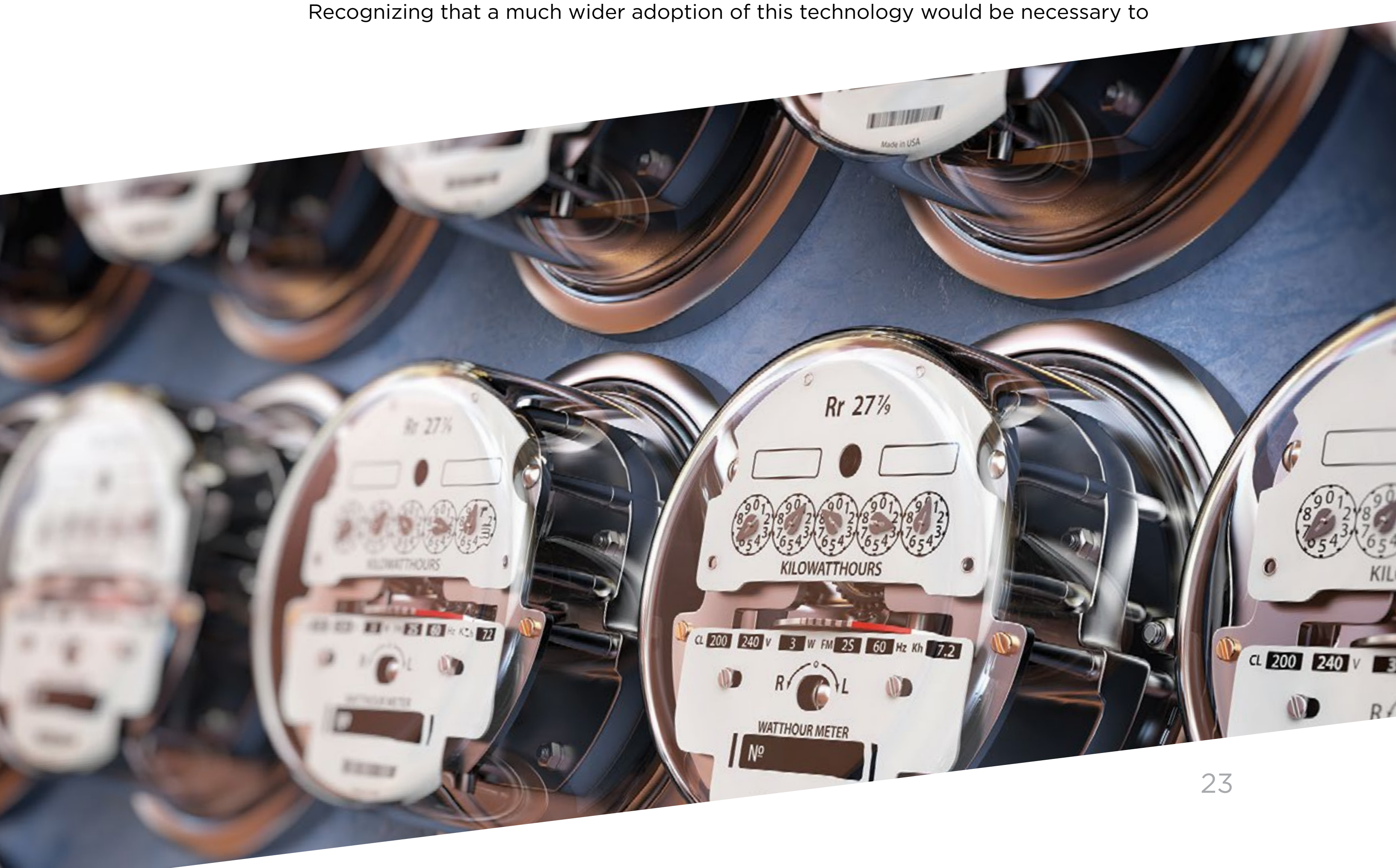
The effectiveness of audits and retuning policies in driving owners to act to improve their buildings is beyond the scope of this report. This section focuses instead on the potential value to city governments of the three types of asset data—equipment and systems inventory, list of recommended energy conservation measures, and end-use breakdown data—and discusses cities' options for collecting that data through an ASHRAE Level 1 or Level 2 audit, retuning requirement, or other methods.



3.1 Equipment and Systems Inventory

From a government analyst's perspective, the most valuable asset data to collect is an inventory of the equipment and systems that affect the amount of energy consumed by a building. A high-quality inventory should contain detailed information on the equipment used for heating, cooling, domestic hot water, mechanical ventilation systems, lighting, the building envelope, generating equipment, and process and miscellaneous loads. This data has a number of valuable uses, as listed below.

- With an equipment and systems inventory, a government analyst can **identify prevalent but outdated systems in the building stock that represent ripe opportunities for energy savings**. Local governments can use this information to create programs that encourage replacement of those systems with more efficient ones. As an example, in New York City, an analysis of the equipment and systems inventory revealed that nearly 75 percent of the city's total audited building area used steam heating systems, representing a prime opportunity to reduce energy use through modernization or replacement. This insight led directly to the city's Steam Heat Campaign, described in *Section 2: Cities Requiring Action*.
- An equipment and systems inventory **enables tracking of the proliferation of energy-saving equipment and technology,** such as air source heat pumps, lighting controls, and submeters. Over time, the inventory data will show the adoption rate of such technologies across the city's covered buildings. This provides a measure of the success of general and equipment-specific market transformation efforts. In New York City, analysis of the equipment and systems in use in audited buildings showed that highly efficient heat pumps provided cooling for approximately 15 percent of the audited building area. Recognizing that a much wider adoption of this technology would be necessary to



meet the city's greenhouse gas reduction goals, New York City's Retrofit Accelerator launched a program to install heat pumps in large commercial and multifamily buildings. In addition to this program, the city began working with equipment manufacturers to encourage development of better-performing heat pumps for the New York City market. In future years, the equipment and systems inventory data will reflect the progress of this work. While most U.S. cities do not have the resources to launch their own market transformation initiative such as this, they can use equipment and systems inventory data to petition their utilities or public utility commission to develop programs that aim to speed up adoption of high-efficiency equipment in local large buildings.

- Achieving deep energy efficiency savings from large buildings requires building owners to make significant efficiency improvements by replacing major pieces of equipment. For major systems such as chillers or boilers that have useful lives of 30–40 years, it is critical that building owners make end-of-life replacements that are not only substantially more efficient, but that where possible, they also invest in other energy efficiency measures that can reduce the demand for cooling or heating and thus enable replacement with a smaller system. Missing too many of these opportunities for substantial energy savings will seriously degrade a city's ability to achieve its energy reduction and climate goals. **By including fields for equipment's age and condition, city government can predict approximately when buildings' equipment will need to be replaced**. This creates an opportunity to develop outreach strategies or additional policy requirements aimed at maximizing the potential energy that can be saved when equipment is replaced.

By working with benchmarking data and equipment and systems inventory data, cities can analyze how different types of systems affect energy consumption in common building types. Cities can use regression analysis to compare the distribution of energy use in buildings with various types of equipment to see if buildings with more efficient equipment actually use less energy than similar buildings with less efficient equipment.

3.1.1 ASHRAE Level 1 or 2 Audit

As discussed in *Section 2: Cities Requiring Action*, there is some variation in the types of audits required by U.S. cities. Some cities require an ASHRAE Level 1 audit, which entails a site inspection of the building and an assessment of its energy bills to identify no- and low-cost energy saving opportunities. Most cities with audit laws base their requirement on the ASHRAE Level 2 audit, which calls for a more detailed investigation, involving energy and financial analysis to identify all of a building's financially viable energy efficiency improvements.

Cities with audit requirements based on either an ASHRAE Level 1 or Level 2 audit should collect an equipment and systems inventory from each audited building. According to ASHRAE Standard 211, in both Level 1 and Level 2 audits, the energy auditor must make a site visit, or walk-through, of a facility. As part of this work, the auditor must "identify major energy using systems, processes, and equipment" and document "control strategies and equipment information of major components from nameplates, as-built drawings, or other means."[19] For a Level 2 audit, the only additional work in this regard that Standard 211 directs an auditor to do is to add further detail to the documentation that was or would have been completed during a previous Level 1 site visit. In other words, both an ASHRAE Level 1 and Level 2 audit afford a jurisdiction the same opportunity to collect an inventory of the systems and equipment in audited buildings.

3.1.2 Retuning or Tune-Up Requirement

Despite the difference in focus between an audit and retuning, both procedures rely on an engineer or otherwise qualified professional visiting the building and assessing its equipment and operational characteristics with respect to energy performance. This makes a retuning requirement a good opportunity for cities to collect equipment and system data as well. As an example, the city of Seattle requires a "tune-up specialist" to record the type, age, and condition of the primary heating system, cooling system, lighting technology, ventilation system, distribution system, and domestic hot water system for up to five of the largest space uses in the building. Additionally, Seattle collects information on the characteristics of the building's envelope, including the construction of the walls and roof, the existence of insulation in both, the percentage of single-paned windows, and the presence of a building automation system.

In comparing the data collection workbooks used by New York City and Seattle for collecting buildings' equipment and systems inventory through their energy audit and retuning requirements, respectively, one can see that the scope and granularity of the data collected is only slightly greater in New York City's case. A comparison of the data collected through these policies is included in *Appendix A: Comparison of NYC and Seattle Equipment Inventory Workbooks*.

Recommendations for Local Governments

An equipment and systems inventory should be collected by every jurisdiction that has an energy audit (based on ASHRAE Level 1 or Level 2) or retuning/retrocommissioning law

Though they differ in their focus and level of effort, all of these processes involve a qualified professional entering a building and investigating its systems and equipment for inefficiencies, defects, and deferred maintenance. In this way, each provides an opportunity for local government to collect valuable information about the buildings in its community. Jurisdictions should implement a data collection process that directs building energy professionals to record an inventory of the systems and equipment used.

Consider whether an audit or retuning policy best aligns with the needs of the jurisdiction

Jurisdictions considering adopting an energy audit or retuning requirement that wish to benefit from the analytical possibilities of equipment inventory data, as well as immediate operational energy savings from corrected defects, may benefit from adopting a retuning requirement instead of an audit requirement. With a solid data collection mechanism that assures collection of the desired equipment and systems information from complying buildings, retuning requirements can be used to collect the most useful data set delivered by energy audits, the equipment and systems inventory, while also correcting operational defects that waste energy in buildings.

3.2 Recommended Energy Conservation Measures

In a voluntary energy audit or retuning, the most valuable output of the process from the owner's perspective is the auditor's list of recommended ECMs. For a mandated energy audit or retuning, the list of recommended ECMs has two purposes. The first is to motivate building owners to invest in their buildings' energy performance to capture the potential return on investment represented by the recommended improvements, though it remains a question whether or not the ECMs in a mandatory audit inspire action among building owners that would not have conducted the audit out of their own volition. The second purpose is for the city to examine the list of measures in aggregate to identify the most prominent opportunities for reducing energy consumption in buildings.

Such information could be useful to cities by **showing what local energy auditors or retuning agents consider the most reasonable opportunities for saving energy in the city's buildings**. Cities can take professionals' recommendations and work to develop programs that promote, incentivize, or otherwise facilitate adoption of these measures by building owners. However, the city would need to define what a reasonable opportunity is so that energy professionals are working from the same set of assumptions.

In New York City's experience, auditors tended to recommend measures with relatively low energy savings and quick paybacks, even though other studies demonstrate ample opportunity for energy reductions in the city's buildings, a proposition supported by the city government's observations of significant savings realized by participants in the NYC Carbon Challenge.[18] Acknowledging that further study is needed to understand why the auditors' recommendations were so modest in scope, the city and its research partners posit one possible reason: the language of Local Law 87 calls for auditors to identify "reasonable measures," which auditors may be interpreting as those measures that the owner is most likely to implement. Regardless of the reason, the modest savings opportunities identified by auditors limits the utility of the ECM data, as it sheds only minimal light on the opportunities for deeper energy reductions, on the scale that will be necessary to meet New York's goal of 80 percent carbon reductions by 2050. Jurisdictions wishing to use auditors' recommended conservation measures to uncover the common ECMs that also have the potential to yield deep savings should consider strategies for ensuring that auditors make ECM recommendations with this purpose in mind. Cities could consider taking a more prescriptive tack in their ordinances or administrative rules by **directing auditors to identify measures with longer payback periods or the most cost-effective package of measures estimated to achieve a specified level of energy savings**. These changes would likely need to be accompanied by extensive outreach and guidance to the city's energy auditors to explain the purpose and reasoning behind them.

Cities could use the auditor's ECM recommendations to get a sense of how much it would cost building owners to reduce their buildings' energy use to align with citywide goals. For example, a city could write into law or regulations that the energy audit should record the recommended combination of ECMs that would reduce a building's energy consumption by 20 percent. With information on common retrofit packages that lead to significant energy savings, cities could work to influence the design of state and utility energy efficiency programs to support those measures. They could also use this information to design prescriptive energy improvements that could be used as a compliance path for future policies that mandate energy improvements, such as a building performance standard. Taking this approach would demand a significant amount of outreach to the city's energy auditor workforce to inform them of the audit requirement's intent. Even with such guidance and outreach, cities would need to be wary of the quality of auditor recommendations, as New York City has reported significant variation in the quality of audits performed for buildings complying with its audit requirement.

3.2.1 ASHRAE Level 1

In a standard ASHRAE Level 1 audit, the energy auditor is required to provide a list of recommended energy conservation measures to the facility owners upon completion of the audit. Auditors should list all identified low- and no-cost measures, defined as measures that can be implemented within the building's operations and maintenance budget. In addition, auditors should also identify and prioritize potential capital improvements that would improve energy efficiency. For each recommendation, the auditor should provide a "preliminary qualitative estimate of the level (high, medium, low) of potential costs and energy cost savings" based on the auditor's field observations.

3.2.2 ASHRAE Level 2

As in a Level 1 audit, an auditor conducting a standard Level 2 audit produces an initial list of recommended operational and capital measures based on field observations made during the on-site survey of the building. This list may be longer or more detailed than if the auditor had conducted a Level 1 audit, as the Level 2 procedure calls for a more in-depth investigation of the facility. The auditor then makes preliminary calculations to estimate the likely savings and costs of the measures on the initial list. The best-performing measures are then singled out for deeper analysis. For these measures, the auditor calculates the energy savings according to a defined methodology or using a building energy model, estimates the cost of implementation by accounting for factors such as material costs, labor costs, permits, taxes, etc., and conducts an economic analysis which calculates the simple payback and return on investment. After a quality assurance review, the auditor presents a final list of recommended ECMs to the building owner.

3.2.3 Retuning or Tune-Up Requirement

According to the PNNL, building retuning, also known as a tune-up, is “a systematic process to identify and correct building operational problems that lead to energy waste” that focuses on identifying low- and no-cost opportunities to improve operational efficiency.[20] A retuning can be described as a lighter version of the retrocommissioning process[21] designed to deliver operational savings at a significantly lower cost.

In a building retuning, the retuning agent conducts an assessment of the building’s equipment, systems, and operational and maintenance processes for improvements that would boost the efficiency of the building’s operation. During this process, the retuning agent should check for the presence of common operational deficiencies found in buildings, correcting the least-costly ones such as inefficient temperature set points or clogged filters, and identifying and recommending voluntary measures to resolve deficiencies for which repair would exceed the scope of standard maintenance. These recommendations can be collected by the local

government as a record of the operational energy conservation measures available in retuned buildings. As an example of the latter type of recommendation, Seattle's tune-up data collection workbook directs agents to note indications of significant air-balancing issues and to recommend rebalancing if significant efficiency or comfort improvements could be achieved. Table 4 lists the items that Seattle tune-up agents must check in their assessments of a building's HVAC and whether or not the corrective action for each item is required or voluntary.

Table 4: **List of Assessments for Seattle's Tune-Up Policy**

Assessment Element	Corrective Action	Required or Voluntary Implementation
Review HVAC equipment schedules (including daily, weekly, seasonal, day/night, occupied/unoccupied hours).	If deficiency is found, did you set schedules to optimize operations for actual building occupancy patterns?	Required
Review HVAC set points (including space temperatures, supply air temperatures, CO2, boiler temperatures, chilled water temperatures, economizer changeover temperatures, and building pressure).	If deficiency is found, did you set or adjust to optimize function and energy efficiency of operations as appropriate to support the building use and occupant needs?	Required
Review reset schedules (including supply air temperature, supply air pressure, boiler and chiller water temperature, lockouts with outside air temperature, loop differential pressure).	If deficiency is found, did you establish or adjust schedules as appropriate?	Required
Review optimal stop/start capabilities.	If deficiency is found, did you implement optimal start/stop capabilities as appropriate to support the building use and occupant needs?	Required
Verify that HVAC sensors are functioning, calibrated, and in appropriate locations. Identify where sensors should be repaired, adjusted, calibrated, or moved.	If deficiency is found, did you adjust or calibrate sensors as appropriate? Or did you recommend repairs/replacement? Adjusting or calibrating sensors is required; Implementation of repairs is voluntary.	Required
Verify HVAC controls are functioning as intended.	If deficiency is found, did you adjust control sequences as appropriate for current facility requirements?	Required
Review HVAC controls for unintended or inappropriate instances of simultaneous heating and cooling.	If deficiency is found, did you adjust HVAC controls to reduce or eliminate any unintended or inappropriate simultaneous heating and cooling?	Required
Note any indications of significant air-balancing issues (e.g. wind-tunnel effect).	If deficiency is found, did you recommend rebalancing of HVAC air and water systems where significant efficiency or comfort improvements can be achieved?	Voluntary

Assessment Element	Corrective Action	Required or Voluntary Implementation
Identify areas with indications that ventilation rates may vary significantly from ASHRAE 62.1 standards and be inappropriate for current facility requirements (e.g. no outside air supply or 100% outside air supply).	If deficiency is found, did you recommend an analysis of ventilation system?	Voluntary
Identify zones that are dominating multi-zone system operations.	If deficiency is found, did you recommend solutions to isolate these zones?	Voluntary
Verify HVAC equipment (such as grills, coils, and ducts) is clean and adequately maintained according to ANSI/ASHRAE/ACCA Standard 180–2012 (or current edition).	If deficiency is found, did you clean where adversely impacting system performance?	Required
Check filters and strainers.	If deficiency is found, did you clean or replace filters and strainers where appropriate and where they are adversely impacting system performance?	Required
	If deficiency is found, did you recommend maintenance protocols as appropriate? Refer to ANSI/ASHRAE/ACCA Standard 180–2012 (or current edition).	Voluntary
Verify that equipment observed during the assessment is in good working condition (such as motors, fans, pumps, belts, pulleys, bearings, and steam traps). Refer to ANSI/ASHRAE/ACCA Standard 180–2012 or current edition).	If deficiency is found, did you repair as appropriate where doing so is generally a standard or regular maintenance action?	Required
	If deficiency is found, did you recommend repairs or replacement if scope of work is more than standard maintenance?	
If ducts and pipes are visible and accessible, verify that HVAC duct and pipe insulation is in place.	If deficiency is found, did you recommend installation or repair of insulation as appropriate?	Voluntary
Check valves and dampers.	If deficiency is found, did you adjust according to ANSI/ASHRAE/ACCA Standard 180–2012 (or current edition) if not opening and closing fully?	Required
Identify equipment approaching the end of its service life, per ASHRAE Service Life Database.	If deficiency is found, did you recommend replacement plan and schedule as appropriate?	Voluntary

Recommendations for Local Governments

Consider the level of audit best suited to balance the city's goals and the local political climate

As an alternative to mandating ASHRAE Level 2, a city may wish to adopt a Level 1 audit, which is less expensive for owners and thus requires less political capital to mandate,[22] or a retuning requirement, which can generate a list of recommended operational ECMs, an equipment and systems inventory comparable to an ASHRAE Level 2 audit, as well as tangible energy savings from corrective actions taken during the retuning process.

Encourage auditors to recommend implementing deeper-saving ECMs

Cities that require AHSRAE Level 2 audits and collect ECM data from them should theoretically collect a more robust and reliable set of ECMs than cities with Level 1 audits. However, in practice, these cities must also be wary of the quality of the ECM data they collect. While cities can rely on many local auditors to conduct audits in accordance with ASHRAE standards, others may not be as thorough or careful in their calculations, or may limit their ECMs to the low-hanging fruit that can often be identified in ASHRAE Level 1 audits. Cities considering an ASHRAE Level 2 audit requirement should plan strategies for assuring the quality of the audits conducted in compliance with the requirement. Such strategies could include:

- Providing training on the audit requirement to local energy efficiency professionals and firms
- Developing a list of service providers that the city deems qualified to conduct an ordinance-compliant energy audit, although this depends on the city having the authority and willingness to do so. The city of Boulder took this approach by requiring building owners to use energy service providers that meet minimum professional qualifications and have completed a 30-minute online training on the specifics of the city's building performance ordinance
- Coordinating energy efficiency-related training and networking events to prepare a community of building owners, property managers, energy professionals, and other interested parties to meet not only the requirements and intent of the audit law, but also the city's long-term building performance goals

3.3 Breakdown of Energy Consumption by End Use

An end-use breakdown is an estimate of the portions of a building's total energy consumed by specific end uses (e.g., space heating, domestic hot water, space cooling, ventilation, etc.). Benchmarking data is limited in this regard, as it can only tell an analyst how much energy a building uses as a whole by summing the consumption of each fuel source. With a breakdown of how much energy common end uses consume across a large portfolio of buildings, an analyst can see how energy consumption is distributed by end use. In New York City, this analysis revealed that in multifamily properties, the majority of energy (approximately 66 percent) was used for heating and domestic hot water. In offices, more than half of the energy used is for non-thermal electric loads, such as lighting and plug loads.[18] This information could be useful for working with utility and government partners to prioritize energy efficiency programs targeting certain types of high-energy end uses in buildings.

3.3.1 ASHRAE Level 2

A standard ASHRAE Level 2 energy audit is the only city-required procedure that calls for the practitioner to conduct an end-use breakdown.[19] According to ASHRAE Standard 211, the energy auditor is required to calculate an estimate of the energy used by each of the facility's major end-use systems "according to its size, load, method of control and efficiency of equipment, and its operating hours," using an energy model or sub-metered data, if available.[19] Cities that already have an ASHRAE Level 2 energy audit requirement and wish to collect end-use energy estimates only need to create a data collection process that requires the auditor to report the estimated energy used by all or a subset of the various end uses defined by ASHRAE (i.e., space heating, space cooling, air distribution, water distribution, solar hot water/domestic hot water, conveyance, lighting, plug loads, process loads, refrigeration, cooking, information technology, other).

An important factor that can limit the value of end-use breakdown data collected from a Level 2 audit is the quality of individual end-use estimates made by energy auditors. Because submetering at the system or equipment level is an uncommon practice, energy auditors must estimate energy consumption for each end use, often using spreadsheet models.[23] The accuracy of these models is entirely dependent on the skills and assumptions of the energy auditor. An added complication is the variation in how auditors treat tenant equipment in a legally mandated energy audit. New York City reported that only a minority of auditors reported on tenant systems, while most only considered base building systems in their estimates, meaning that the city's portfolio-level end-use breakdown may not accurately account for energy used by tenant systems.[18]

3.3.2 Inverse Modeling with Monthly Data

Cities that do not have ASHRAE Level 2 requirements or that wish to avoid some of the data quality issues associated with the end-use consumption modeling by energy auditors could explore using monthly fuel data from benchmarking (now available to city governments through ENERGY STAR Portfolio Manager) and inverse modeling techniques to estimate end-use breakdowns. By observing the sensitivity of a building's fuel consumption to changes in weather, this type of analysis can separate out a building's heating load, cooling load, domestic hot water load, and base electric load (i.e., lighting, plug, and miscellaneous loads). While less granular than the breakdown estimated by a Level 2 audit, this information, when applied across a portfolio of buildings would still show where certain building types might have unexpectedly high base loads or domestic hot water loads. The cost of doing this analysis on a city's entire portfolio of covered buildings would likely outweigh the benefit of these insights; however inverse modeling data would also allow the city to identify buildings that appear especially ripe for energy efficiency projects targeting heating, cooling, or base loads. This information could be used to help existing government- or utility-sponsored energy efficiency programs promote their services to buildings with high savings potential. For more on how inverse modeling with monthly data could be used by governments, see *Using Monthly Energy Data from Benchmarking Programs*.

3.3.3 Research Surveys and Models

Estimates of how much energy certain end uses consume in common building types could likely be gleaned from sources that do not require modeling the loads within individual buildings. Academic and professional research papers, surveys, and models may be available that would give government analysts an adequate understanding of how energy is used within buildings in their area. This information, when combined with other types of asset data, such as an equipment and systems inventory, could be just as valuable as auditor-modeled end-use breakdowns in identifying priority end uses for future energy efficiency programming.

Recommendations for Local Governments

Work with auditors to improve reliability of end-use breakdown estimates

End-use breakdown data collected from required ASHRAE Level 2 audits is useful for revealing minor insights about how energy is used in a community's buildings, such as those found by New York City and for presenting a graphical breakdown of energy consumption by major end uses by building type. Beyond that, its value seems to be limited, in part due to concerns about the quality of the estimates submitted by energy auditors. Cities with ASHRAE Level 2 audit requirements that wish to collect end-use breakdown data should consider ways to work with auditors to improve the reliability of their estimates.

Investigate alternate data sources

With or without a Level 2 requirement on the books, cities should investigate whether research and modeling already exist that provide a reliable estimate of how energy is used in common local building types. Those cities that also have the opportunity to work closely with administrators of energy efficiency programs should also consider using monthly fuel use from benchmarking reports for inverse modeling analysis. This technique potentially provides value in two ways: first, cities and their partners can use it to identify buildings that likely have inefficiencies in their heating or cooling systems or that have abnormally high gas or electric base loads. This can make enrollment in efficiency programs more cost-effective. Second, with inverse modeling, a city analyst can disaggregate buildings' energy end uses, though at a lower level of resolution than the end-use breakdown in a Level 2 audit.

Explore data analysis software tools that estimate energy consumption by end use

Cities interested in understanding energy consumption by end use and where promising opportunities for energy savings exist within the local building stock may find value in new analytical tools that estimate this information. The U.S. Department of Energy's Asset Score tool generates a report showing, among other things, a building's source and site energy use breakdown by end use and opportunities for improvement.[24] The New Buildings Institute's First View® software relies on data included in ENERGY STAR Portfolio Manager benchmarking reports (plus monthly energy consumption data, newly available to jurisdictions collecting benchmarking reports) to disaggregate general end uses (heating, cooling, electric baseload, and gas/steam baseload) and recommend likely sources of inefficiency within those end uses based on a simulation model of the building. For more information on FirstView and its potential applications for local governments with benchmarking ordinances, see *Using Monthly Energy Data from Benchmarking Programs*.

APPENDIX A
Comparison of New York City and Seattle Equipment Inventory Workbooks

The following table outlines the data collected through New York City and Seattle's audit data collection policies as of the most current data collection workbooks at the publication of this report.

System Category (if applicable)	System/Equipment Type	New York City[25]	Seattle[26]
Heating Systems and Equipment	Primary System	Type Fuel Source Quantity Equipment Tag Number Spaces Served Controls Age (Year installed) Condition	Type Fuel Source Spaces Served (up to 5) Age (estimate within 5 years) Condition
	Burners	Type Quantity Age (Year installed)	
	Distribution Systems	Type	Type (up to 5) Age (estimate within 5 years) Condition
	End-Use Equipment/ Terminals	Type Controls	*Included in distribution systems*
	Domestic Hot Water	Type Quantity Equipment Tag Number Spaces Served Age (Year installed) Fuel Source Controls Domestic hot water (DHW) from space heating boiler?	Type (up to 5) Age Condition

System Category (if applicable)	System/Equipment Type	New York City[25]	Seattle[26]
Ventilation	Ventilation	Exhaust Systems Location Spaces Served Quantity	Type (up to 5) Age Condition
		Equipment Tag Numbe Age (Year installed)Motor horsepower **Supply Systems** Type Economizer Location Spaces Served Quantity Motor HP	
Lighting	Lighting Systems	Lamp Type (up to 5) Location Ballast Type Approximate Area Covered	Primary Lighting Technology (up to 5)
	Interior Lighting Controls	Type (up to 5) Approximate Area Covered	
	Exterior Lighting Controls	Type (up to 5) Approximate Area Covered	
Envelope	Exterior Walls	Wall Types (up to 5) Above Grade Wall Area Vertical Glazing (% of Wall)	Main Wall Type Are walls insulated? R-Value (if known)
	Windows	Framing Material (up to 5) Number of Panes Glass Coating Type Operable? Sealant and Weather Stripping?	Percentage of windows that are single-paned
	Roof	Roof Type Roof Area Pitch Roof R-Value Terraces/Setbacks as % of Roof Terraces/Setbacks R-Value Alternative Roof System Skylight Area (% of roof area)	Main Roof Construction Is the roof insulated? R-value (if known) Is the attic/space ceiling insulated if different than roof? R-value (if known)

System Category (if applicable)	System/Equipment Type	New York City[25]	Seattle[26]
Other	Irrigated Area		Outside irrigated area of 500 sq. ft. or more? Total irrigated area Is irrigation sub-metered?
	Building Automation System	Controls data collected in heating, cooling, DHW systems categories	Building Automation System? Direct Digital Control or Pneumatic?
Generating Equipment	Cogen/CHP	Type (up to 5) Peak Generating Capacity Fuel Estimated Operating Hours per Year Year Installed	
	Renewables	Type (up to 3) Year Installed Peak Generating Capacity	
	Back Up Generation	Type Peak Generating Capacity Fuel Year Installed Used for Demand Response?	
Process/ Miscellaneous Loads	Data Center	Total Gross Area Metered Space Connected Load UPS Capacity Power Usage Effectiveness	
	Trading Floor	Total Gross Area Connected Load	
	TV Studios	Total Gross Area Connected Load	
	Broadcast Antenna	Connected Load	
	Commercial Kitchen	Connected Load Total kBTU/hr. for all equipment	
	Times Square Signage	Connected Load	
	Miscellaneous Process Loads	Connected Load Total kBTU/hr. for all equipment	Describe significant energy uses and their energy source. Describe additional significant process water uses.

APPENDIX B
Acronyms

ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BPS	Building Performance Standards
CEM	Certified Energy Manager
CPC	Community Preservation Corporation
CRM	Customer Relationship Management
CUSP	New York University's Center for Urban Science and Progress
DC	District of Columbia
DER	Distributed Energy Resources
DHW	Domestic Hot Water
DOE	U.S. Department of Energy
ECM	Energy Conservation Measure
EER	Energy Efficiency Report
EERE	U.S. DOE Office of Energy Efficiency and Renewable Energy
ESPC	Energy Savings Performance Contract
GHG	Greenhouse Gas
HVAC	Heating, Ventilation, and Air Conditioning
IMT	Institute for Market Transformation
LL84	NYC's Local Law 84: Benchmarking
LL87	NYC's Local Law 87: Energy Audits and Retrocommissioning
NEMA	National Electrical Manufacturer's Association
NGO	Nongovernmental Organization
NYC	New York City
PE	Professional Engineer
PNNL	Pacific Northwest National Laboratory
RCx	Retrocommissioning
RECs	Renewable Energy Certificates
TBD	To Be Determined
US	United States
USGBC	U.S. Green Building Council

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Endnotes

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