ABC
A BETTER CITY

Virtual Energy Assessments

An Emerging Technology to Understand Building Energy Use and Opportunities

FEBRUARY 2014

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A Better City improves the economic competitiveness and quality of life of the Boston region by advancing and providing leadership on significant transportation, land development, and environmental policies, projects, and initiatives related to the commercial real estate sector.

The Green Ribbon Commission's Commercial Real Estate Working Group is a group of leading Boston property owners who are working to help the City meet the aggressive goals of its Climate Action Plan.

ABC's Challenge for Sustainability engages Boston businesses to adopt best practices in sustainability and energy efficiency through a platform of benchmarking and a peer support network to reduce their carbon footprint.

For additional copies of this report please visit ABC's website at: *www.abettercity.org*.

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COVER PHOTOS

(Top) © NREL/SunPower. *(Bottom, clockwise from upper left)* © NREL/Bill Timmerman, © NREL/Katrin Scholz-Barth, © iStockphoto/jwilkinson, © iStockhpoto/kadmy

Summary

Remote or virtual energy assessments are an emerging technology that provides building owners with a greater understanding of their building's energy use and operations using inputs from utility meters and computer modeling. Building owners are investigating the technology as an affordable alternative to more comprehensive walk-through energy audits, which can cost tens of thousands of dollars, and provide a level of complexity and detail unneeded by some owners. State and local governments are also interested in virtual energy audits as a tool for rating building performance or as a compliance option for energy reporting ordinances.

A Better City (ABC) is a Boston-based, non-profit organization that represents the interests of the business and institutional community on issues of transportation, land development, and the environment. The focus of this study is related to the Commercial Real Estate sector. ABC was interested in learning more about virtual energy assessments and conducted a pilot program with nine properties within Boston. These properties included Class A and B office buildings of various sizes and ages. ABC wanted to investigate how useful the results of the virtual energy assessments were to building operations and management staff; if actionable improvements and opportunities were identified; the limitations of the technology; and if the technology was a viable alternative to more expensive walk-through audit requirements. With funding from the Barr Foundation, ABC partnered with Retroficiency, a Boston-based remote energy auditing company for the pilot.

Retroficiency's virtual energy assessment successfully identified building energy use patterns and provided specific, actionable recommendations to achieve energy savings.

- Pilot participants reported that information provided by Retroficiency complemented and enhanced existing knowledge of their building's energy use profile.
- Pilot participants also reported that the information provided insights on how to move forward with efficiency projects in their spaces.
- These results suggest that virtual energy audits may be a potential cost-effective compliance route for the energy audit requirements of Boston's energy reporting and disclosure ordinance.
- The results also suggest that virtual energy audits are a way for building owners to identify opportunity areas in their operations to meet commercial sector emissions reduction targets, which could lead to greater energy efficiency improvements.

Introduction

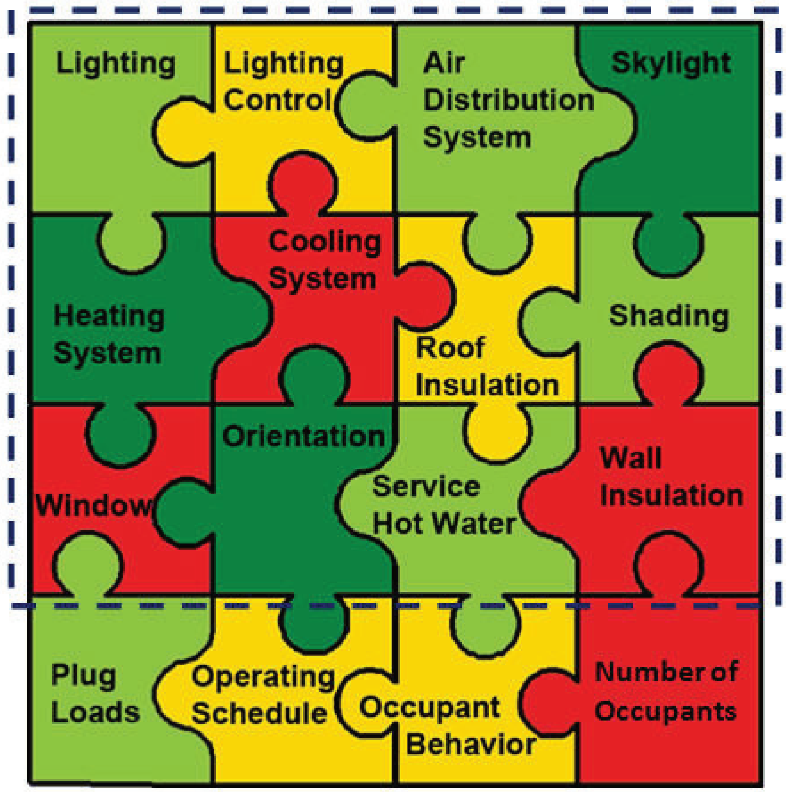
A Better City works to improve the economic competitiveness and quality of life in the Boston region by advancing and providing leadership on significant transportation, land development and environmental policies, projects, and initiatives related to the commercial real estate sector. ABC supports the Boston Green Ribbon Commission, an organization comprised of leaders from Boston's key economic sectors who advise the City on its Climate Action Plan and policies, and demonstrate peer leadership by implementing best practices in their respective sectors. ABC provides staff support for the Commission's Commercial Real Estate Working Group (CREWG) which engages property owners and building managers from Boston's major institutions and buildings.

The City of Boston established aggressive greenhouse gas emission reduction goals as part of its 2011 Climate Action Plan, with the buildings sector expected to provide 24 percent of the plan's emissions reductions. Understanding and identifying cost-effective strategies that will help property owners, tenants and building managers reduce energy consumption will be key to reaching the City's climate goals. Energy efficiency will play a central role in achieving reductions across Boston's building stock and encouraging market adoption of new technologies that will be accessible to a range of building owners will be crucial for further efficiency gains. Virtual energy assessments/audits represent an emerging, cost-effective technology which allows property owners to receive targeted energy-efficiency recommendations with minimal financial outlay. Additionally, the City of Boston will begin implementation of its Building Energy Reporting and Disclosure Ordinance (BERDO) in May 2014. This new policy will require large buildings to publicly disclose energy and water use and potentially complete either an energy-efficiency audit or energy retrofit activity every five years. Finding cost effective ways to identify energy savings opportunities will be crucial to the success of this new policy and to the City's success in meeting its 25 percent greenhouse gas emissions reduction goal by 2020.

The Evolution of Energy Auditing

FIGURE 1

Building Asset Rating: An image by the Department of Energy illustrating the delineations in building energy use divided by building assets and building operations. Building assets are denoted by the dotted line.



SOURCE: DEPARTMENT OF ENERGY

Virtual energy audits are an emerging energy efficiency technology. Software companies such as FirstFuel, SPARC, and Retroficiency have developed methods to remotely monitor building systems, and provide property managers with detailed information about building operations and energy use. The information from these virtual audits would traditionally be obtained through more labor intensive walk-through audits.[1]

Walkthrough audits are conducted via site visits by a qualified energy services professional. These audits can be used to identify inefficiencies in building operations and assets, such as chillers, boilers and lighting fixtures. A common type of walkthrough audit is the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Level-2 audit, which can cost tens of thousands of dollars for a large building. An ASHRAE Level-2 audit provides information to building owners on:

- Specific building assets or operational practices which can be improved,
- Energy conservation measures that would reduce consumption,
- Cost-estimates for implementing measures and their savings,
- Information on active incentive programs and rebates in the area.

Virtual energy audit software uses databases compiling information on local weather conditions, energy performance of similar buildings, statistics and 15-minute interval utility data to provide data visualizations of building energy use, benchmark building performance and provides both operational and equipment-related recommendations. These audits can provide owners with insights to target areas to further investigate or promote investment in conservation actions. Virtual energy audits may not be able to provide recommendations at the specificity of a walk-through audit, but they can provide building owners with valuable energy intelligence at a lower cost. One major advantage of virtual audits is their ability to rapidly asses a building's energy profile. According to Retroficiency, once data is received, analysis time takes only minutes per building and thousands of buildings can be processed simultaneously.

There has been increasing interest in applying virtual energy audit technology at the local, state and federal levels. The federal government is working to apply remote auditing technology through internal programs and with external partners. The U.S. Department of Energy's Building Technologies Division has developed a tool to remotely assess building assets. The Commercial Building Energy Asset Score tool provides building owners with peer benchmarking information on in-building systems and recommendations on potential upgrades. The government tool uses building information and utility bills to run an energy model.[2] Additionally, the U.S. General Services Administration (GSA) has partnered with First Fuel, a virtual energy audit software company, to provide audits to interested facilities managers in GSA buildings. The First Fuel web-based interface gives managers quick access to a rapid assessment of their building operations based on utility data.[3] The distinction between energy contributions from building assets and operations is described by Figure 1. Reductions in both attributes are necessary for a comprehensive approach to energy efficiency.

In Massachusetts, the Department of Energy Resources (DOER) is currently implementing a Building Asset Rating pilot that explores cutting-edge energy auditing technologies. The first phase of the pilot was designed to compare traditional walkthrough audit results with innovative remote auditing technologies. Each of the eleven commercial buildings in the pilot received a traditional ASHRAE Level-2 audit and an assessment by one of the pilot technologies. Each of the innovative technologies constructed a customized model of energy use for each building. The pilot indicated that the three pilot technologies could provide building assessments at a significantly lower cost when modelers had access to consumption data, modeling software, and the building site to validate results. The new technologies' costs averaged $8,000 dollars per assessment, a significant reduction from the $25,000 average from the walkthrough audits.[4] The second phase of the pilot will use two technologies developed by the Weidt Group and Retroficiency on a larger sample size of buildings.[5]

In May 2014, the City of Boston's Building Energy Reporting and Disclosure Ordinance (BERDO) will take effect. The regulation requires that property owners report their energy and water usage on an annual basis, and either perform an energy audit or make an energy efficiency investment every five years. Virtual energy audits may be able to offer a low-cost compliance pathway for building owners who are interested in understanding target areas to increase energy efficiency, but may find a traditional audit cost-prohibitive. These building owners may choose to follow-up with a traditional energy audit for more specific information after modifying their operations, or integrate walkthrough audits into the capital improvement process.

About the Virtual Energy Assessment Pilot

ABC's Virtual Energy Assessment Pilot was funded through a grant from the Barr Foundation as part of a larger initiative to engage the commercial real estate sector in achieving energy and greenhouse gas emission reductions. ABC evaluated several remote energy audit technologies and chose to partner with Retroficiency, based on their reputation within the industry and their interest in working closely with ABC to further test their software within the commercial real estate sector. Retroficiency offers a range of audit products including a low-cost virtual energy assessment and a more advanced software-based audit that includes an on-site assessment. The pilot deployed

FIGURE 2

Savings potential for a sample building portfolio through the Retroficiency online interface

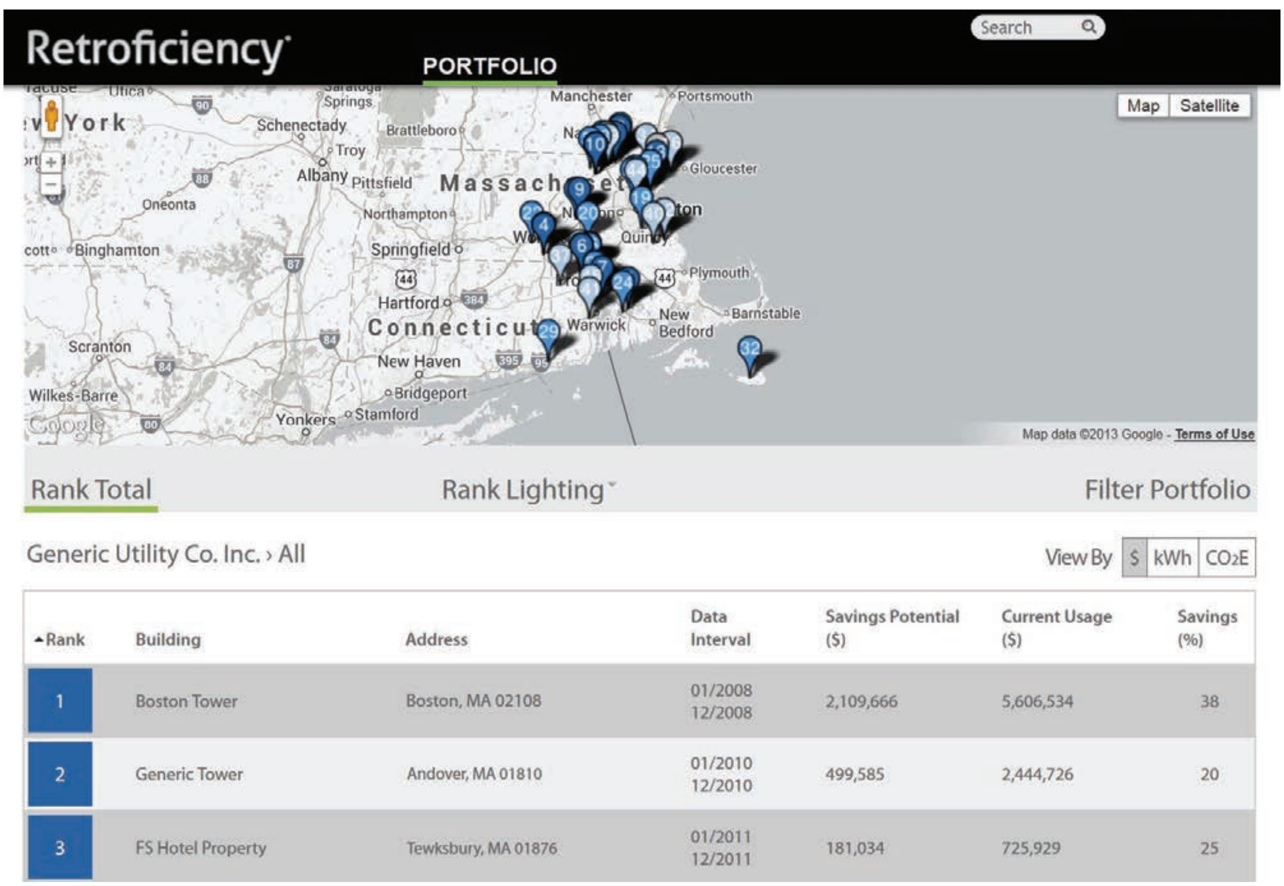
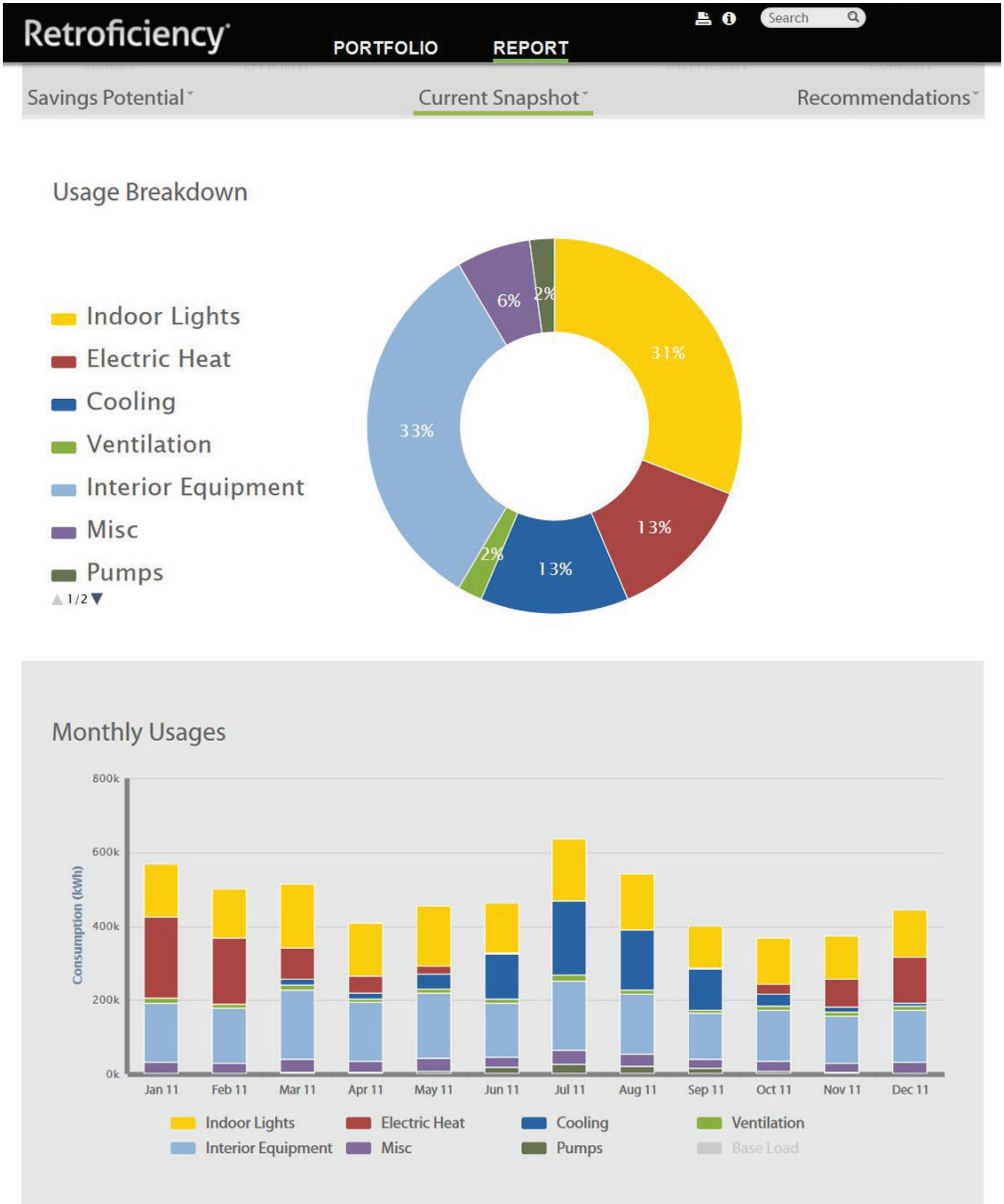


FIGURE 3

Graphs depicting annual energy use breakdown for a sample building.

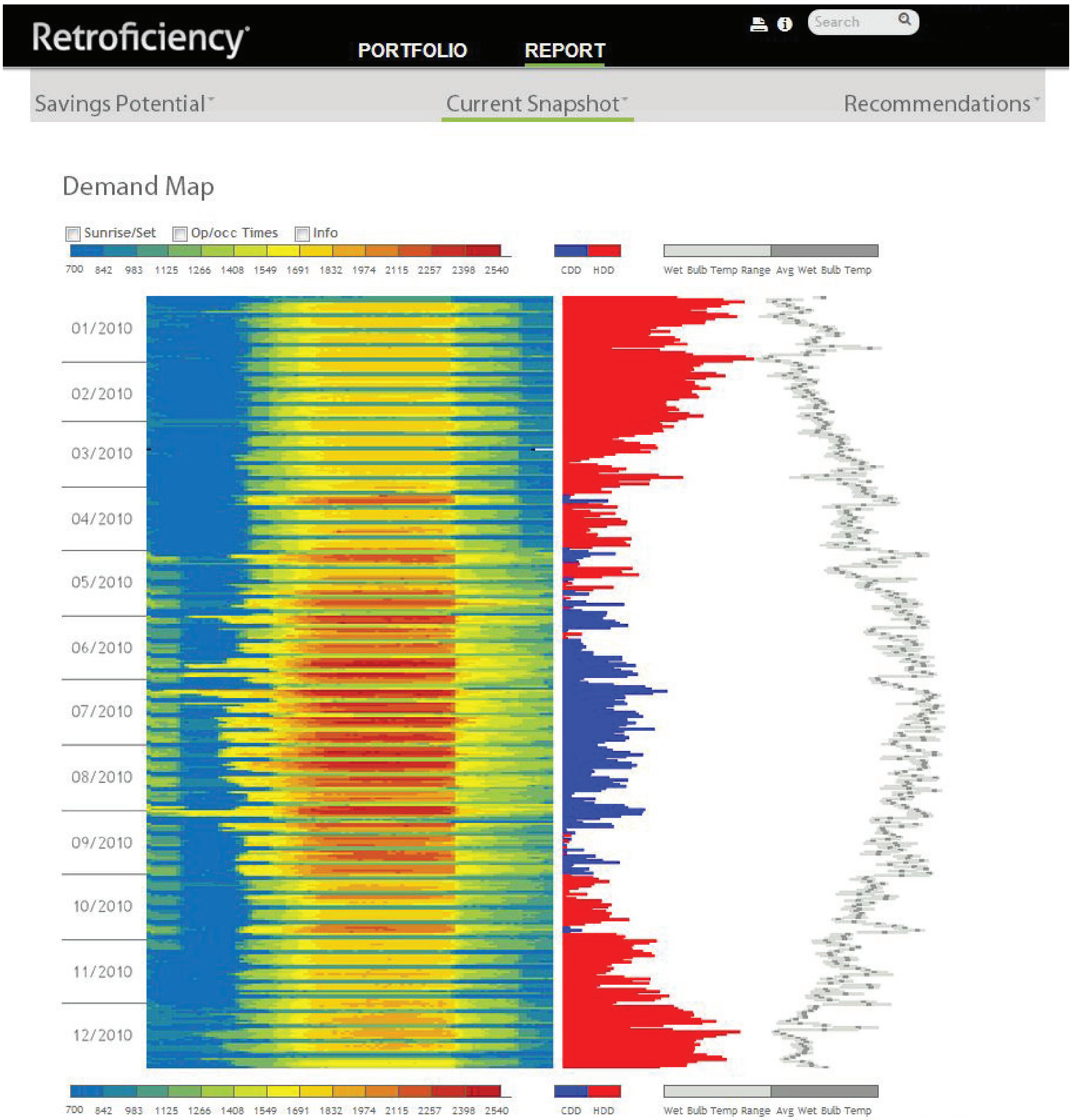


the low-cost virtual energy assessment, which was priced at $800 per building. In order to conduct these assessments, Retroficiency required the property owner to provide at least twelve months of building utility 15-minute (or hourly) interval data. Because the audits use advanced algorithms to identify building energy performance characteristics, granular utility data is needed. NSTAR customers, primarily those in larger properties, have advanced energy meters that report electricity consumption at 15-minute intervals back to the utility. This high-resolution data is ideal for use with virtual assessment technologies.

Participants for the pilot were recruited from ABC's membership as well as from members of the Boston Green Ribbon Commission. Unfortunately, several ABC members who

FIGURE 4

Heat map depicting energy demand in the Retroficiency web interface. The image was taken from Retroficiency's website on its Virtual Energy Assessment.



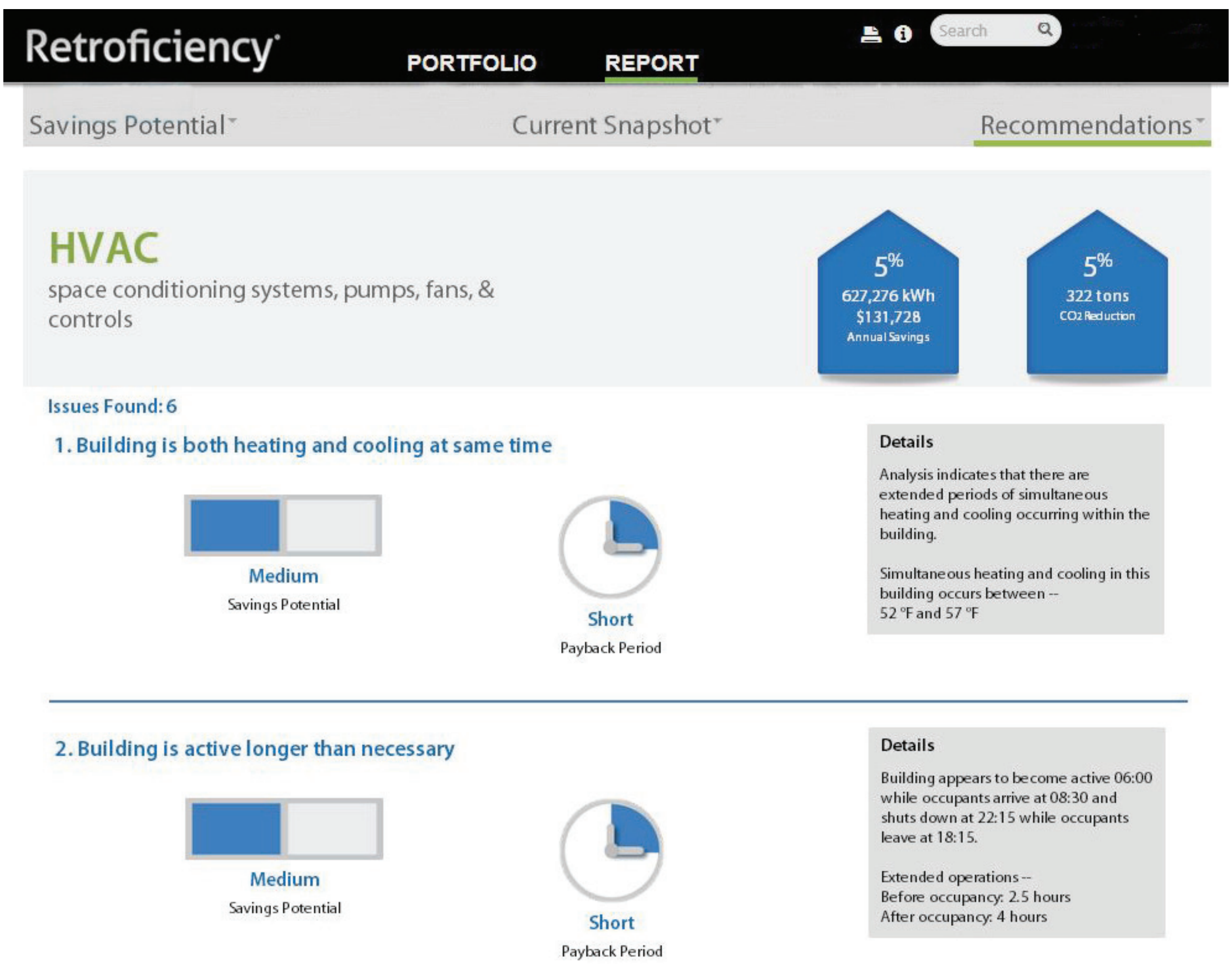
had a strong interest in participating in the pilot were unable to do so as their properties were not equipped with the advanced energy meters required to gather interval data. Each pilot participant worked with ABC to request utility data from their electric, gas and steam provider. This typically required the building owner or property manager to submit a simple form releasing the data to ABC. Once the data was provided by the utilities, Retroficiency typically provided audit results within one week.

After completing its assessment, Retroficiency provided each building owner with access to the assessment results through a password-protected web portal, which provides added data security. Additionally, a follow-up call with the property manager was held to provide an in-depth review of the assessment results and the features of the web portal. During these sessions, participants were able to ask questions about the methodology and gain insights into the recommended intervention areas provided by the assessment. The information from the Retroficiency web-portal is divided into three key parts.

- **Savings Potential for Portfolio:** The landing page for the Retroficiency web interface provides summary information for all virtual assessments conducted across a building portfolio. Building owners or property managers can view each building's savings potential, which is determined comparing the building under evaluation to an efficient peer, and current energy use. Clicking on an individual building will navigate users to more detailed building information. Potential cost savings and recommendations for improvements are identified by category (i.e. HVAC, Plug Loads, Lighting, Refrigeration) on each individual building page (see Figure 2, p. 5).

FIGURE 5

Sample recommendations page in the Retroficiency web interface. The image was taken from Retroficiency's website on its Virtual Energy Assessment.



The virtual energy assessment results for the nine participating buildings identified the potential for $1,431,487 in annual savings from energy efficiency interventions. Retroficiency identified significant savings potential in other buildings that had not yet pursued energy conservation as intensely.

- **Energy Use Breakdown:** Individual building reports provide detailed information on annual energy usage through graphical analysis. The interface presents monthly summary data to users with sub-categorizations of energy usage (See Figure 3, p. 6).

- **Building Energy Use:** This section provides data visualizations of energy use in the building based on utility interval data. It also breaks down building energy usage. A key component of this section is a heat map which provides a detailed look into the buildings operations based on energy use (see Figure 4, p. 7). The heat map uses a color scale to represent the amount of energy being used in a building every 15 minutes for each day of the year. Red denotes a period of high energy use, while blue denotes less energy use.

- **Recommendations:** The recommendations section provides suggested action steps for facilities managers to reduce energy use from HVAC systems, plug loads, lighting and refrigeration. These recommendations are accompanied by information on the payback period, greenhouse gas emissions reductions, and energy savings (see Figure 5, p. 8).

Virtual Energy Assessment Results

Nine properties, totaling more than 5.1 million square feet were audited as part of the pilot. This included six office properties covering a total of more than 2.8 million square feet and three hotels totaling more than 2.3 million square feet. The virtual energy assessment provided a breakdown of energy use for each property. The breakdown included kWh, kBtu, and steam data. Figure 6 shows the composite electricity use breakdown for the six office properties in the pilot and Figure 7 shows the composite electricity use breakdown for the three hotels. As the figures show, lighting and plug loads make up the majority of electricity consumption for both property types.

The virtual energy assessment results for the nine participating buildings identified the potential for $1,431,487 in annual savings from energy efficiency interventions. Several buildings in the pilot program had invested heavily in energy efficiency prior to the virtual audit; savings identified for these buildings were quite small, with the best performing property having no identified savings opportunities. Retroficiency identified significant savings potential in other buildings that had not yet pursued energy conservation as intensely. The highest identified annual cost saving for any building was $765,169. The average annual savings for the entire portfolio was $178,935.90. The pilot identified a total of 7,211 tons of CO2e reduction potential,[6] resulting in an average reduction of 901.4 tons of CO2e per property. For the participating properties, this was equivalent to identifying an average greenhouse gas reduction of 9.9 percent per building. These emissions reductions would result in substantial cost savings for building owners and tenants, as well as contribute to the City's overall emissions targets.

Recommendations for improving each property's energy performance were provided for HVAC, plug loads

FIGURE 6
Composite electricity consumption breakdown for six pilot office properties.

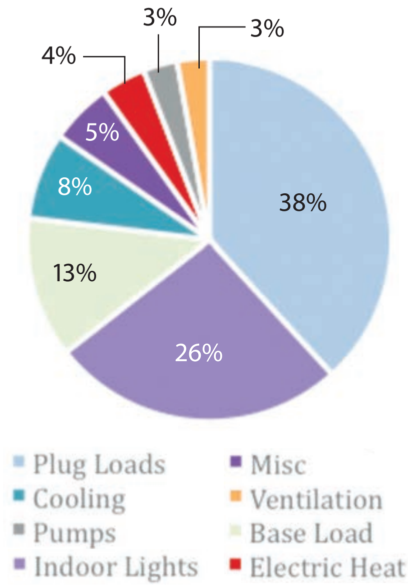
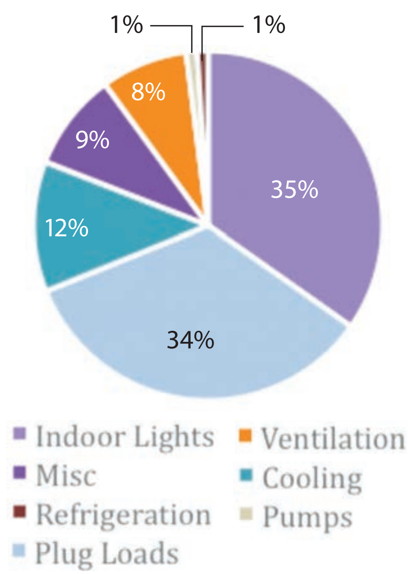


FIGURE 7
Composite electricity consumption breakdown for three pilot hotel properties.



and lighting. The virtual assessments found a total of 3,326 tons of potential greenhouse gas savings through HVAC improvements, 2,510 tons through plug load energy reductions and 1,261 tons of emissions savings potential through lighting retrofits. A summary of the estimated potential greenhouse gas emissions savings for each property is provided in Figure 8. The virtual energy assessment identified potential savings for six of the nine participating buildings. Some properties were deemed to be highly efficient and were outperforming buildings with average operations and equipment.

Table 1 shows the projected annual savings values for the entire building portfolio for each type of efficiency measure. As the table illustrates, HVAC recommendations had the highest average annual savings per energy conservation measure, while plug loads had the second highest savings per measure. It is important to note that, while the virtual energy assessments suggest that building base loads (e.g. large servers) might present energy savings opportunities at several properties, the audits do not quantify the potential benefits for that energy savings category.

In all cases, the virtual energy assessment was completed with interval data from the electric utility. After participants discussed their results with Retroficiency during a webinar presentation, several buildings returned to their steam providers to request interval steam data for their properties. In four cases, the addition of steam data increased the efficiency performance of the building, and thus the virtual energy assessment identified significantly less savings opportunities. In one case, the addition of steam data made the building appear less efficient. When the Virtual Energy Assessment initially determines issues found in a building based on just interval data and an address, the software generates a list of potential measures for investigation that may help remedy the issue. In some cases, these potential measures may not be relevant to the building. For example, one building which was steam heated and cooled received a recommendation to investigate installing variable frequency drives (VFDs) and pumps, which are not necessary for steam systems. It is therefore important that these potential measures be positioned properly to the building owner when the initial report is delivered and that relevant questions are asked by Retroficiency to avoid a lack of confidence with the software's results and recommendations.

In another case, a building utilized chilled water for cooling, and their building owner was unable to make available interval data for chilled water consumption. Without this data, the virtual energy assessment identified this building as a low potential property on an electricity consumption basis. However Retroficiency, A Better City and the facility manager later deemed there may be savings opportunities as a complete picture of the building's energy usage was not available. This example illustrates the need to take into account the full context of virtual energy assessment results when data for only one fuel is available.

FIGURE 8

Potential GHG savings for each building.

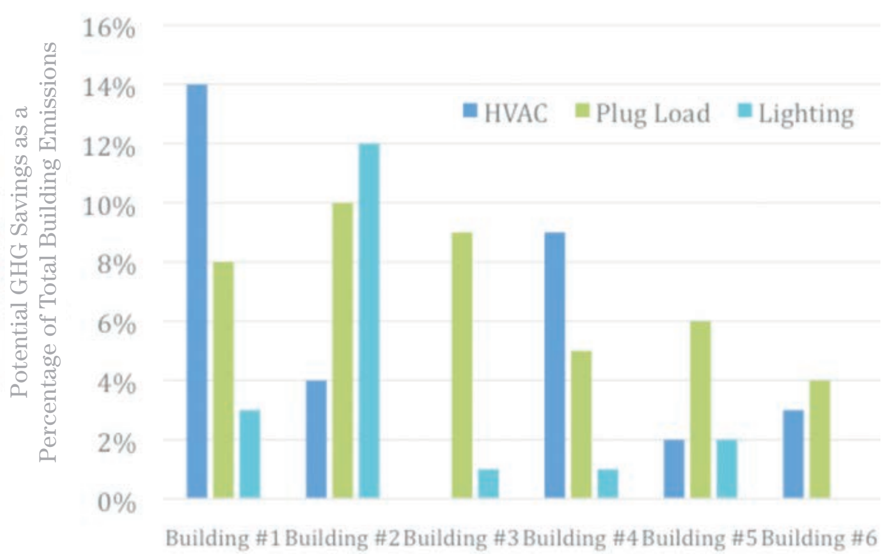


TABLE 1

Energy conservation measure recommendations by type for the pilot portfolio.

	HVAC	Plug Loads	Lighting	Base Load
Number of Recommendations	4	6	6	2
Total Savings from Recommendations	$501,848	$543,229	$293,014	N/A
Average Savings Per Recommendation	$167,283	$108,645	$58,603	N/A

Participant Interviews

Following Retroficiency's webinar presentations, ABC requested Meister Consultants Group (MCG) to conduct interviews with pilot project participants to better understand their perceptions of the virtual energy assessment. Interviews were structured to discuss participants' experiences with traditional energy audits, existing energy efficiency programs in their buildings, and the effectiveness of the virtual energy assessment. All of the interview subjects were responsible for energy management in their buildings and represented engineering and facilities management departments.

All participants reported that they had a positive experience working with Retroficiency, and expressed surprise at how much information the virtual energy assessment was able to provide without an on-site audit. Building owners remarked that the information was of similar quality to their in-house energy management and assessment tools. Many participants indicated they were investigating the action areas that the recommendations identified. Additionally, the hour-by-hour energy use heat map (Figure 3), provided an accurate, easily digestible picture of annual operations in the building.

Several concerns were raised with the recommendations provided by the virtual energy assessment. Energy managers expressed frustration with plug load recommendations since they believed there was little they could do to influence tenant behavior, although new solutions and treatments focused on tenant behavior are emerging to address this issue. Facilities managers in buildings that utilized steam expressed concern that the energy model and its accompanying recommendations did not seem to mesh with unique needs of buildings that are steam heated and cooled. Other managers expressed disappointment that their buildings received no recommendations. However, these buildings were identified by Retroficiency as having no potential energy efficiency savings as the properties had already made significant energy efficiency investments.

Even in these cases, building managers said that the information provided by Retroficiency was of significant value. In many buildings, walkthrough audits were not conducted frequently, and the virtual assessment provided a quick way to gain intelligence on building operations. Interviewees also felt that the information Retroficiency provided could be easily communicated to management and non-technical members of the building staff. Several interviewees had used the energy use heat map to review energy issues with management even in the absence of recommendations. Facilities managers responded that Retroficiency enhanced or integrated with their existing building management systems and provided useful building-specific recommendations which complemented benchmarking programs like Portfolio Manager or their own internal assessment systems. Finally, participants suggested that the inclusion of recommendations for buildings which were considered highly efficient would improve the usefulness of the platform.

Conclusions and Next Steps

The virtual energy assessment pilot was generally viewed as a positive experience by the participating building owners. Participants were presented with user-friendly data on their annual energy use and, in some cases, advice on how to proceed with further efficiency projects. However, if the pilot program were to continue, there are several potential areas for modifications and improvements.

Interval utility data was requested directly by building managers and then passed on to Retroficiency. This process produced a lag, especially for steam data. If Retroficiency and ABC could work together to integrate direct utility data uploads into the assessment tool, it would save building managers' resources, and speed up the turnaround time of the virtual assessment results. NSTAR's Green Button platform, which is intended to provide utility customers with easy access to their consumption data, is a potential avenue to accomplish this as Retroficiency can already accept Green Button data. NSTAR has implemented the Green Button data download service for some customer classes; however this service was not available to pilot participants. Additionally, a reliance on interval data excluded interested building owners from the pilot whose buildings lacked interval meters. This group included several Class B buildings owners. Smaller properties in Massachusetts often do not have access to interval utility data; further pilot programs and outreach to Class B properties must consider this limitation and develop appropriate procedures for virtual energy assessments to be more inclusive of these properties.

The pilot largely worked with building owners that are actively engaged in managing the energy performance of their properties, and this was evidenced by the fact that several participant buildings were amongst the best-performing properties Retroficiency had ever audited. Future virtual energy auditing efforts should consider targeting Class B building owners who,

Retroficiency's low-cost virtual energy assessment service could provide building owners with a robust understanding of their building's energy performance and could help prioritize energy efficiency investments.

unlike the pilot participants, may not have regular access to detailed energy management data. Retroficiency's low-cost virtual energy assessment service could provide these building owners with a robust understanding of their building's energy performance and could help prioritize energy efficiency investments. However, these buildings may not be equipped with proper metering equipment by the utility to enable the collection of granular interval data. These buildings may be better candidates for rapid on-site audits using tools such as automated energy audits which do not require interval data but have a higher cost.

For potential expansion of the pilot program, and as a possible next step, Retroficiency can supplement the virtual assessment results with their automated energy audit process, which uses algorithms to streamline a walkthrough energy audit. These walkthroughs could provide property managers with detailed information on potential improvements and serve as a way to add value and identify longer payback opportunities for buildings which the virtual assessment indicated were highly-efficient.

Recommendations

The results of the pilot program have provided ABC with new insights into the benefits and potential uses of virtual energy assessments and remote auditing. These insights have led to two key recommendations. Class A building managers in the pilot had access to and employed a variety of energy management technologies, but still learned new information from their virtual assessments, providing evidence that these assessments can provide value with regard to energy efficiency at a reasonable cost to the consumer. As the City of Boston moves forward with implementing the Building Energy Reporting and Disclosure Ordinance (BERDO) in May 2014, they could consider the use of this technology for complying with the regulations as virtual audits are a demonstration of a property owner's active commitment to reduce energy use. Currently, a walkthrough audit at the ASHRAE Level-2 standard is an allowable method of complying with the ordinance, but virtual assessments are not included as a compliance pathway. Remote energy auditing technologies can be paired with streamlined walkthrough audits to offer similar results to ASHRAE Level-2 audits at a lower price-point. Remote audits can also provide facilities managers with information on how to manage their energy use. As such, it is recommended that the City of Boston, and other municipalities that may decide to implement similar ordinances in the future, consider and investigate these technologies as alternatives, especially for smaller interval-metered buildings that may not have the resources to devote to an ASHRAE Level-2 audit. Boston's ordinance allows property owners and service providers to suggest alternatives to traditional energy audits, and Retroficiency may want to propose their technology as a potential alternative compliance pathway in the near future.

Additionally, the results from the virtual assessments in this pilot emphasized the importance of managing plug loads. Plug loads represent a significant portion of energy use in commercial buildings and a target for interventions. Tenant engagement and plug load reductions are currently under-incentivized by utilities and existing programs. It will become increasingly difficult for the City of Boston to achieve its emission reductions targets without targeted energy conservation measures for plug loads. The Challenge for Sustainability program developed by A Better City works with property owners and tenants to set energy targets and awards participants for completing sustainability actions. The City of Boston could collaborate with A Better City to work towards expanding the program to buildings affected by the early implementation phase of BERDO and to engage utilities to fund and develop aggressive plug load reduction programs.

ENDNOTES

1 Lacey, Stephen. *Intelligent Efficiency: Innovations Reshaping the Energy Efficiency Market.* Green Tech Media. Special Report. 2013.

2 U.S. Department of Energy. *Commercial Building Energy Asset Score.* Building Technologies Office. Washington, D.C. June 2013.

3 Business Wire. *U.S. General Services Administration Selects FirstFuel Software to Drive Comprehensive Energy Efficiency in U.S. Buildings.* Lexington, Massachusetts. October 29, 2013.

4 Northeast Energy Efficiency Partnerships. *Building Asset Rating. Massachusetts: Raising the "BAR" to Improve Energy Efficiency.* Website. 2013

5 Northeast Energy Efficiency Partnerships and Massachusetts Department of Energy Resources. *Raising the BAR: Building Asset Rating in Massachusetts.* Webinar Presentation. January 29, 2013.

6 This unit represents equivalent carbon dioxide, a common measure of global warming potential. It represents the quantity of a mixture of greenhouse gases in terms of the warming potential of CO_2 over time. For instance, methane, a more potent greenhouse gas, has a ratio with CO2 of approximately 1:25.

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